MALE/FEMALE COGNITIVE SKILLS: AN ANALYSIS OF THE PARAMETERS REGARDING THE NATURE AND DEGREE OF THE DIFFERENCES

BY

LOIS HALSEY COOKE

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This dissertation is dedicated to my sons Larry and Randy, who put up with an abnormal life for several years so Mom could further her career, and to my late husband, whose unfaltering faith in my capacities and abilities, both as a woman and as a person, has had an immeasurable impact on my life.

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MALE/FEMALE COGNITIVE SKILLS:
AN ANALYSIS OF THE PARAMETERS REGARDING THE NATURE AND DEGREE OF THE DIFFERENCES

By

Lois Halsey Cooke

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This study investigated the nature and degree of cognitive differences between males and females. Cognitive differences have been reported in professional journals and the popular press, particularly in the areas of verbal and visual/spatial skills. First the study considered the interchangeable terminology encountered in the literature, listed the categories of terms, and arrived at working definitions for the purposes of the study.

The second consideration of this study concerned the historical perspectives regarding male/female cognitive differences. The centuries-old mind set of differential cognitive skills for each sex was traced from the time of Plato up to the present. A tie-in was made between this mind-set, the historical values attached to right and left sides of the body, and the present day assignment of function to resident skills of the left or right hemisphere.

The study looked at limitations of the research into male/female cognitive differences, the theories which purport to explain the differences, and the various factors which can impact on cognitive development. A descriptive account was carried out on a representative group of tests which have demonstrated male/female cognitive differences. Those tests were analyzed by a specified format and were then evaluated as to effective useability. A list was provided of those examined tests which were considered to meet the minimum specified criteria for consideration and inclusion in future investigations.

The study concluded that an extremely cautious approach must be used when reading research results on male/female cognitive differences. This approach is necessitated by the built-in limitations of much of the available research and the inadequacy of many present-day tests to accurately measure the skill under question regarding male/female cognitive differences. Additionally, the between-group differences that were found on the skills in question were small and insignificant when compared to the differences which exist within-group. Suggestions for follow-up research were made that could eliminate some of the problems encountered at present in investigations of male/female cognitive differences.

CHAPTER ONE
THE RESEARCH PROBLEM

Background for the Study

Popular and scientific interest in the brain, its physical components and the functions of its various parts is not a twentieth century phenomenon. By at least the mid-nineteenth century, scientists were devoting their skills to the study of the brain, and their findings were appearing in the popular literature of the day. Many of the studies were concerned with showing male/female differences in brain size, brain weight and brain site function. The past decade has presented an apparent resurgence of interest in the brain and its functions as evidenced by the many articles featured in professional journals and popular magazines. This interest appears to have been generated by research in the 1950's on the two hemispheres of the brain.

In the fifties, pioneers in the field of brain research developed a new surgical procedure to prevent severe epileptic seizures. They separated the brain's two hemispheres by severing the connecting nerve fibers. While studying the effects of the surgery on those patients whose corpus callosum had been split, scientists such as Bogen (1969a, 1969b), Bogen & Bogen (1969), and Sperry (1975) developed novel techniques to study the separate functions of the two hemispheres. The information generated from those "split-brain" studies captured the imagination of professionals and the general public alike.

Medical and psychological journals were flooded with articles on various aspects of the brain and its functions. Educational journals followed suit, and "right-brained," "left-brained" became new buzz-words in educational literature. Surgeons and medical researchers, publishing in educational journals, described the messages from the laboratory regarding educational implications of recent brain research (Bogen, 1977; Sperry, 1975-76). Trade and commercial magazines were quick to pick up on the tempo of the times and published their own brand of research reports on information generated in the "split-brain" laboratories.

One spin-off from the growing body of information concerning brain research was a concept about male/female differences in the physical as well as functional organization of the brain and the impact of those differences on male/female cognitive behaviors. The concept of male/female differences in the composition and function of the two cerebral cortexes of the brain led to popular generalizations about cognitive differences that are often tenuous in their relationship to the original research.

Differences between males and females, particularly in the areas of cognition, have been well-publicized and generally well-accepted. These apparent male/female cognitive differences have been reported in professional publications and leading text books as "fact," as "well-researched," and as "well-documented" (Block, 1976a; Fairweather, 1976; Hyde, 1981; Maccoby & Jacklin 1974). In general, females have been described as more verbal and left-brain dominant and males as more spatial and right-brain dominant. This belief is founded in part on the reported male/female differences in brain organization and function; however, when trying to draw out the practical implications of information presented in professional journals and popular magazines, one becomes aware of the lack of empirical data for much of what is reported. There also exists in past and current literature strange twists of logic concerning attributes assigned to the sexes. To avoid constructing invalid conclusions or drawing faulty inferences from what is reported on male/female cognitive differences, a comprehensive analysis of the status of knowledge and research about these differences is needed.

Need for the Study

To examine the area of male/female cognitive differences, it is helpful to attend to several conditions which could affect the outcome of the examination. Those existing conditions are

1. The impact of historical observations about male/female cognitive differences and their relationship to current research and knowledge in the field of cognition.
2. The emergence of theories which attempt to identify and document male/female cognitive differences and which are frequently contradictory.
3. Research findings of male/female congitive differences which are frequently contradictory, or derived from research which is often biased, inadequate or inappropriate.

4. The attention which is given only to brain organization and specialization when investigating male/female congitive differences, to the exclusion of other important variables.
5. The lack of agreement on the terms used to describe research about male/female cognitive differences, which leads to confusion in any attempt to synthesize the results.
6. The far-reaching social and educational effects that generalizations from research on male/female cognitive differences can have. These research generalizations usually address male/female differences in verbal and visual/spatial skills. This is a major area which is documented extensively and which reports "well-known" male/female cognitive differences. There is disagreement about the validity of those generalizations as well as the adequacy of the measures used to assess the verbal and visual/spatial skills.

Much of what is discussed and studied about male/female differences in cognition is highly controversial, misinterpreted and misunderstood. This creates general confusion among educators when they try to identify instructional strategies which translate from research to practice. Decisions regarding guidance, vocational counseling, courses of study and middle school organization, for example, could result from beliefs in some of the research results (see Epstein, 1978; Epstein & Toepfer, 1978; Hyde, 1981; McGee, 1979).

Conflicting results are acknowledged to exist in studies of male/female cognitive differences. Why do these conflicting results exist? If some answers could be provided for this basic question, then a more accurate picture might be sketched of the actual status of male/female differences in cognition. In this way practical knowledge may be distilled from that information.

As a result of considering the above conditions, it became apparent a need existed for a study which would (a) consider the major contributing conditions, factors and theories affecting research about male/female cognitive differences, (b) describe and discuss those conditions, factors and theories, (c) describe and analyze test instruments in the area of verbal and visual/spatial skills as they pertain to male/female cognitive differences, and (d) extract implications for future instruction and research and practical and theoretical knowledge development. The present study addresses these facets of the area of male/female cognitive differences.

Purpose of the Study

The purpose of this study is to describe and evaluate the status of knowledge regarding male/female cognitive differences. The following questions are addressed:

1. What perspectives about male/female cognitive differences have existed historically? What influences have these perspectives had on popular knowledge, theory, and research?
2. What major theories are currently being used to explain male/female cognitive differences? What are their underlying bases? What discrepancies exist about these theories?
3. What criteria could be used to judge the adequacy of knowledge and research methodology concerning male/female cognitive differences?

4. What factors could influence the development and expression of cognitive abilities, particularly the verbal and visual/spatial skills, and could lead to the research studies' suggestions of male/female cognitive differences?

5. What actual differences have been reported regarding male/female performance on measures of verbal and visual/spatial skills? What is the nature of the tests used to measure those cognitive skills?

6. What conclusions and implications can be identified from the knowledge and research about male/female cognitive differences?

Definition of Terms

When reading the literature and research reports on male/female cognitive differences, the variety of terms encountered may confuse the reader. Many different words, or variations of those words, are used interchangeably to denote similar or duplicate meanings. When authors use a variety of words or phrases interchangeably in the same article, one assumes the purpose was to add interest and avoid redundancy. This may not present a problem to professionals in the various fields concerned with male/female congitive differences, as familiarity with the subject may facilitate the semantic switch. However, for the purposes of this study and in the interest of simplicity, whenever possible one word or phrase is used throughout to represent a class of words or phrases. Those interchangeably used words and phrases are presented below. Following discussion of the words or phrases in each category, the representative word or phrase will be given, accompanied by its selected definition.

The reader is still left with the problem of determining the meaning intended by the original author cited. This problem points up a larger question encountered in reading and interpreting research into male/female cognitive differences. How can one synthesize the research when there is uncertainty about the intended definition of the variables in question? This study will attempt to discern the intended definition from the larger context in which the material was found. If this approach is not satisfactory, the assumption is then made that the original author's definition is the same as that provided in this study. This is not a wholly satisfactory solution to the problem; the importance of a well-defined classification system for research into male/female cognitive differences becomes apparent. Perhaps definitions arrived at through this study will help future researchers struggling with this same problem.

Category One

The first category of words or phrases consists of the following: intelligence, intellectual functioning, cognition, cognitive ability, and cognitive functioning.

The word "cognitive" has had a rather long-standing association with educational terminology. Bloom (1956), when classifying the goals of the educational system, chose the terms "cognitive," "affective" and "psychomotor" when he divided human behaviors into three discrete categories. Although simplistic in nature, that classification system has stood the test of time and is used as the classification system in the majority of training institutions today.

Bloom defined the cognitive domain as the sphere of activity which deals with "recall or recognition of knowledge and the development of intellectual abilities and skills" (p. 7). Sherman (1978) described cognition as "intellectual processes as opposed to motivational and emotional processes" (p. 16). Webster (1979) defined cognition as the "process of knowing in the broadest sense, including perception, memory, judgment, etc." (p. 276). Wittig and Petersen (1979) described cognitive functioning as "those processes by which knowledge is acquired, particularly perception, learning and reasoning" (p. 1). The word "intelligence" appears to be more value- and emotion-laden than "cognition." In the western world it is closely associated with IQ. Sattler (1974) has identified three distinct meanings for the word "intelligence," not all of which can be measured by IQ tests (see Sattler, p. 8). Thus a simple working definition of "intelligence" would be difficult to formulate. It appears as though intelligence can be subsumed under cognition; thus the word "cognition" is used in this study to represent the variety of words and meanings in this cluster of words.

Cognition. Cognition is defined as the intellectual processes, skills, and abilities by which knowledge is acquired, interpreted, organized, stored, retrieved and employed.

Category Two

The second category of words or phrases consists of the following: sex differences, gender differences, male/female differences, sex-related differences, sex differences in behavior, sex differences in cognitive processes, male/female cognitive differences, gender-related cognitive differences and sex-related cognitive differences.

"Sex differences" is the phrase most frequently encountered in the literature when speaking of male/female differences, either for cognitive abilities or other abilities and functions. Sherman (1978) felt the phrase "sex differences" denoted differences attributable to biological sex. "If the differences are not attributable to biological sex, why call them 'sex' differences?" (p. 16).

Since "gender" is a term of social role, "gender differences" can denote differences attributed to social causes. "Gender" is also emotionally-laden with meanings of "masculine" and "feminine," which are not necessarily the same as "male" and "female." Sherman choose the term "sex-related cognitive differences" as it seemed to be the "most clear, easily understood, and neutral term to describe differences observed between male and female groups without implying either biological or social causation" (p. 16).

Sherman's deference for a term which is neutral, clear and easily understood is commendable. However, in the western cultures there is a tendancy to imply a sexual connotation when using the word "sex." Thus Sherman's term, "sex-related cognitive differences," may not be as neutral as intended. Since this study is concerned with looking at only one of the many purported differences between males and females, the term "male/female cognitive differences" was chosen as being the most descriptive and value-free, and is used to represent this category.

Male/Female Cognitive Differences. Male/female cognitive differences is defined as those differences between male and females in cognition or cognitive ability and skill which are assumed to be quantifiably measurable by some standardized instrument. The primary concern of this study is with measured and measurable differences in verbal and visual/spatial skills.

Category Three

The third category of words or phrases consists of the following: verbal skills, linguistic skills, verbal ability, language skills, language ability, left-hemisphere skills.

To arrive at a definitive meaning for this cluster of words and the following two clusters became a major undertaking. Wittig and Petersen (1979) stressed that "the area of verbal skill requires further investigation and the establishment of a clear definition of the term is needed" (p. 11), but make no further attempt to produce a viable definition for the tasks that are measured under the heading of "verbal skills." Geschwind (1974), while wrestling with the problem of adequate definitions, stated that "again and again in the history of science, definitions turn out to be the result of greater understanding of a problem, in contrast to the conventional view that definitions are necessary for the study of a problem" (p. 9). However, in the interest of simplification, one word and its definition are selected for this cluster of words, with the built-in assumption that it will not be entirely satisfactory but may be further clarified by this investigative process.

From the above choices, the term "verbal skills" is probably the most frequently encountered in the literature on male/female cognitive differences; usage of the other words in the cluster appears to depend on the discipline from which the author is speaking. In one of the most comprehensive reviews and summations of the literature on male/female cognitive differences of the past two decades, Maccoby and Jacklin (1974) chose the term "verbal abilities" to describe those "intellectual abilities and cognitive styles" which were distinct from "quantitative ability," "spatial ability," "analytic abilities," "concept mastery and reasoning," "creativity," and "moral judgments" (p. 75-114). No formal definition of "verbal abilities" was given, although the authors did allow that the distinction between verbal and quantitative skills posed problems because numbers are frequently expressed in words, and both can be regarded as symbols (p. 63).

Included under the rubric of "verbal abilities" were measures of spontaneous vocal and verbal behavior taken from two weeks after birth to age 21, as well as results from over 100 studies of "tested verbal abilities" from ages six months to 84 years (p. 76-83). These latter studies covered a wide modal range of presentation of stimuli and elicitation of response.

This study contends that the word "skill" implies a learned trait, while the word "ability" leans more toward the implication of an inherited trait. Thus "skill" will be the word of choice in this study. Webster (1979) has defined "verbal" as meaning "of, in, or by means of words" (p. 1577). This is certainly a more narrow definition than the implication in most research studies as to what has been measured. However, "verbal" is a more inclusive word than "linguistics" for the purposes of this study and because of its broader usage will be the term of choice for the present study.

Verbal Skills. Verbal skills are defined as those skills measurable by a standardized test that deal with the recognition, comprehension, analysis or production of the spoken or written language of the culture under investigation.

Category Four

The fourth category of words or phrases consists of the following: visual, spatial, visuo-spatial, visual/spatial skills or abilities and right-hemisphere skills.

Webster (1979) defined "visual" as "of, connected with, or used in seeing; based on, designed for, or controlled by the use of sight" (p. 1588); "spatial" was defined as "of space; happening or existing in space" (p. 1366). In Getman's visuomotor theory of development, vision is equated with perception (see Lerner, 1976, p. 138). Getman felt vision is the process whereby space is perceived as a whole; vision, in that context, is learned and it refers to one's ability to interpret the world and one's own relationship to the world. Although it is possible to experience the dimension of space without the use of vision (the blind do it haptically; see Maccoby & Jacklin, 1974), in most instances tests of spatial ability involve the use of vision to some degree.

Lerner (1976) outlined Chalfant and Scheffelin's identification of the five component skills within the broad field of visual perception:

1. spatial relations--perception of the position of objects in space, including the placement of an object or symbol and the spatial relation of that object or symbol to others surrounding it

2. visual discrimination--ability to differentiate one object from another, either by color, shape, pattern, size, position, or brightness

3. figure ground discrimination--ability to distinguish an object from the background surrounding it

4. visual closure--ability to recognize or identify an object or stimulus when the entire object or stimulus is not presented

5. object recognition--ability to recognize the nature of objects when viewing them (p. 175-76)

Maccoby and Jacklin (1974) chose the term "spatial ability" when synthesizing the research on intellectual abilities, although they admitted that "spatial ability, even more than verbal or quantitative ability, is difficult to define" (p. 91). They enlarged on what the term might possibilty encompass, but did not provide a definitive meaning. The authors stated that "another issue is whether sex differences in spatial ability are confined to the visual modality" (p. 93). They did divide the "visual-spatial" (p. 93) studies they reviewed into two groups: 1) those dealing with visual, non-analytical ability, i.e., having mainly a spatial component, and 2) those dealing with visual-analytical ability, i.e., involving set-breaking or restructuring.

Harris (1978) reported the following definitions of spatial ability found in literature of the 1940's and 50's:

1. to move, turn, twist, or rotate an object or objects and to recognize a new appearance or position after the prescribed manipulation has been performed

2. to make discriminations as to the direction of motion such as up and down, left and right, and in and out

3. to recognize the identity of an object when it is seen from different angles

4. to think about those spatial relations in which the body orientation of the observer is an essential part of the problem

5. to perceive spatial patterns accurately and to compare them with each other (p. 405).

Harris felt that each definition implied mental imagery, but of a kinetic rather than a static kind. McGee (1979) also preferred the term "spatial abilities," and considered it to have at least two distinct components:

1. spatial visualization--the ability to mentally manipulate, rotate, twist, or invert pictorially presented visual stimuli; it involves the process of recognition, retention, and recall of a configuration in which there is movement among the internal parts of the configuration, or of an object manipulated in three-dimensional space, or the folding or unfolding of flat patterns.

2. spatial orientation--involves the comprehension of the arrangement of elements within a visual stimulus pattern, the aptitude for remaining unconfused by the changing orientations in which a configuration may be presented, and the ability to determine spatial relations in which the body orientation of the observer is an essential part of the problem (p. 3-4).

It is clear from the above definitions that the visual aspect is an essential component in the definition and analysis of spatial ability. The definition provided by McGee appears to encompass all the preceding meanings of the term "spatial ability." In addition, the term "visual/spatial" is more commonly used than any other term in the literature, and assumes the use of the visual mode when dealing with sighted subjects. Thus the term "visual/spatial" is the preferred term to represent this category.

Visual/Spatial Skills. Visual/spatial skills are defined as those skills, measurable by standardized tests, which involve the use of vision and/or mental imagery and which also involve the components of spatial visualization and/or spatial orientation as defined above by McGee.

Category Five

The fifth category of words or phrases consists of the following: cerebral dominance, cerebral lateralization, asymmetry, sexual dimorphism, bilateral representation, bilateral mediation, hemispheric asymmetry, hemispheric specialization, lateralization and hemispheric lateralization.

It is assumed the reader is aware that the outer-most layer of the human brain, which comprises 80% of the brain, is called the cerebral cortex, and that this cortex is divided into two presumably symmetrical halves. The division of the brain runs from front to back so that each half occupies the left and right sides of the skull, respectively. The terms in this cluster have been used to describe the functional differences of those two hemispheres of the brain. Kinsbourne and Hiscock (1978) felt the terms "cerebral dominance" and "cerebral lateralization" were often used interchangeably and without definition or explanation, although there was an essential difference in meaning between the two terms. According to the authors, lateralization could be regarded as a hypothetical construct which cannot be fully measured by any one operation, or it could be used to refer to a very specific behavioral characteristic such as degree of hand preference, which is more easily measurable.

The term "cerebral dominance" came into being during the 19th century, with Paul Broca's discovery that certain areas on the left side of the brain controlled certain language functions. At that time in history, language ability was the predominant measure of intelligence; thus the left side of the brain was thought to dominate the right or mute side of the brain. This early definition, according to Hecaen (1980), meant a function was exclusive to one of the hemispheres due to the specialized centers it possessed, i.e., an absolute dominance. Although considered by some writers as a less modern term than "laterality," the term "dominance" still enjoys popular usage. Lerner (1976), in a book devoted to learning disabilities, defined cerebral dominance as "the control of activities by the brain, with one hemisphere usually considered consistently dominant over the other. In most individuals, the left side of the brain controls language function, and the left side is considered the dominant hemisphere" (p. 425).

The concept of dominance implies that one hemisphere exerts a mastery or control over the other. Since recent research has given little support for that concept, the term "lateralization" is currently regarded as more adequate. Webster (1979, p. 796) defined lateral as "of, at, from, or toward the side; sideways; anything located, done etc. to the side." Blakeslee (1980) defined lateralization as the left-right separation of function of the hemispheres of the brain. Other researchers have redefined cerebral dominance so that it is more in accord with the more narrow definition of lateralization. Geschwind (1974) stated

> A reasonably adequate current definition of dominance might be: one hemisphere may be said to be dominant for a given function when it is more important for the performance of that function than the other hemisphere. The definition is purposely vague, since we do not yet possess all the means necessary for proving the existence of dominance. Nor do we know that the same mechanisms underlie dominance in all instances. (p. 9)

Gazzaniga (1974) stated that cerebral dominance has come to refer to "the phenomenon that usually one hemisphere is specialized for language and speech processes" (p. 367). Galaburda, LeMay, Kemper and Geschwind (1978) believed that "cerebral dominance means that one side of the brain is more important for certain functions than the other side" (p. 51). These definitions approach the meaning assigned to the term "hemispheric specialization." Nebes (1977) felt hemispheric specialization replaced the concept of hemispheric dominance. McCallum and Glynn (1979) held that "hemispheric specialization means that the two hemispheres of the human brain are specialized for different modes or styles of information processing" (p. 263). Cohen (1977) agreed, stating that different cognitive processes are subserved by different hemispheres. The above meanings approximate the word "hemisphericity" coined by Bogen (see Bogen, DeZure, Tenhouten & Marsh, 1972), which means a tendency to rely more on one hemisphere than the other for information processing.

Bogen felt that each hemisphere, rather than being dominant or dominated, was specialized for a particular type of information processing that was less available to the other hemisphere; the hemispheric differences should be considered in terms of process specificity rather than material specificity. Zenhausern (see Note 1) stated that for the most part, the two hemispheres do the same thing, but they do them differently; what differentiates the hemispheres is their processing style. Levy and Reid (1978) believed the hemispheres of the brain were specialized, that each hemisphere was "predominant in a set of functions for which the other was ill designed" (p. 120). Levy and Reid felt there were two complementary brains, each with its own cognitive, and possibly affective processes, and each was superior in functions for which the other was inferior. Although Levy and Reid termed this concept "cerebral asymmetry," the idea is perhaps best described as hemispheric specialization, the term chosen to represent the variety of interchangeable terms presented in this category. Thus, hemispheric specialization is further divided by the introduction of the notion of male/female differences in degree of hemispheric specificity of cognitive functions. In order to avoid a semantical trap, this study relies on the term "hemispheric specialization" and discusses, when appropriate, the degree, if any, of male/female differences in that specialization.

Hemispheric Specialization. Hemispheric specialization is defined as those functional processes of the left or the right cerebral hemispheres which demonstrate that particular hemisphere's capacity to most efficiently handle the task or information presented to the intact individual.

Organization of the Study

The format of this study is pyramidal in structure. The study is broad-based at origin, and narrows down to one specific topic at its end; each succeeding chapter delimits the area of concern. Chapter Two establishes the broad base upon which historical perspectives about male/female cognitive differences have developed. Chapter Three discusses the criteria to be considered when evaluating research regarding male/female cognitive differences. Chapter Four addresses the current major theories being used to explain male/female cognitive differences that have evolved in part as a result of pre-established mind-sets regarding those differences.

The controversy about male/female cognitive differences appears to revolve mainly around differences in verbal and visual/spatial skills, with females being regarded as more verbal and left-brain dominant, and males being regarded as more visual/spatial capable and right-brain dominant. Chapter Five investigates the factors which could influence the development and expression of those cognitive abilities and which could result in appearances of male/female cognitive differences. Chapter Six is concerned with the actual reported male/female differences in performance on standardized measures of verbal and visual/spatial tasks and investigates the nature of the tests used to measure those cognitive skills. Chapter Seven focuses on the conclusions and implications which can be drawn from this narrowing-down process of investigation into the knowledge and research about male/female cognitive differences, particularly those conclusions and implications of interest to educators responsible for teaching and training others.

CHAPTER TWO
HISTORICAL PERSPECTIVES

> And can you mention any pursuit of mankind in which the male sex has not all these gifts and qualities in a higher degree than the female? . . . all the pursuits of men are the pursuits of women also, but in all of them a woman is inferior to a man.
>
> Plato's Republic
> circa 300 B.C.
> Bishop & Weinzweig, 1979

In any study which reports the existence of differences between the sexes, particularly in the area of intellectual processes, one must keep a historical perspective in mind. It is important to look beyond the current data to the forces, both evident and hidden, which may have led to the current status of that data, and to the progressive interpretations of the data as a reflection of each succeeding period in time. Although interest in examining the brain and skull for proof of any cognitive differences between males and females was begun in earnest in the 1800's, the philosophical, cultural, and psychological underpinnings of this area of study were being set forth centuries before the birth of Christ. The early mind-sets which resulted have continued to infiltrate scientific thought and reason, in some form or other, to the present time.

Chapter Format

This chapter will highlight some of the attitudes, beliefs and expressions of leading thinkers from the time of Plato and Aristotle up to the 20th century. The focus of this chapter will be on the position and regard with which females have been viewed cognitively, in comparison with males, since early recorded history. One cannot investigate the historical roots of attitudes towards the cognitive abilities of both sexes without also tapping into the attitudes directed towards one sex in particular.

The first section of this chapter will contain direct quotations from the authors cited in this review, so the reader may interpret and draw his/her own conclusions. When direct quotations are not possible or feasible, reliance must be placed on the accuracy of the reviewer quoted. Generally, a chronological order will be followed, except in those instances where to do so would interfere with the pursuit of an idea, or the making of a point.

In almost all the material reviewed, the expository style has been to compare and contrast, to present the sexes in a bi-polar arrangement. Thus, the second section of the chapter will present the various dichotomies developed cross-culturally through time. Presentation of these dichotomies will help to elaborate upon the silent, unconscious, but potentially dynamic conditioning over the centuries to which males and females alike have been exposed, a conditioning which helps to determine how we view our own and the opposite sex's cognitive abilities.

Cultural and Philosophical Roots

Through a study of Greco-Roman philosophy, in order to find the origins of western attitudes, Ghougassian (1977) developed a thesis about the reality of "cultural unconsciousness" which he believed survives in each of us and which repeats the historical developments of mankind. Ghougassian stated

> I maintain that our present-day history is inextricably interwoven in and dependent upon the past histories of civilization. To know why we are what we are now, and do things the ways we do them--especially in the situation of the sexes--we ought to revert to the historical development of behavior formation, value attitudes and ideas in early Greece, the origin and cradle of the western attitudes toward women (p. iv). . . . Unless the individual becomes aware of the obscure forces that determine his outlook on sex differences, he may remain the prisoner of a social-cosmic-fate. (p. 1)

Plato is regarded by some researchers (Clark & Lange, 1979; Ghougassian, 1977) as an advocate of equality for women, and even considered an early feminist. However, when reading direct translations of his writings (see Bishop & Weinzweig, 1979; Agonito, 1977) Plato appears to be inconsistent in his treatment of women. Plato did advocate equal education for women, but with one rejoinder: those women must be the capable ones, and have the potential for joining the ranks of the guardians, one of the classes of his ideal society. On reading the opening quote to this chapter (Bishop & Weinzweig, 1979, p. 44), the idea becomes apparent that Plato did regard women as inferior to men as a class, although he advocated political and social equality for the sexes.

Aristotle, a student of Plato's, was considered by Ghougassian (1977) as the patron of the philosophical movement of sexism. By studying the biological differences of the sexes, Aristotle reached the conclusion that the female was inferior to the male; an impotent, mutilated male; an accident of nature. For a detailed analysis of Aristotelian logic on male/female differences as regards right/left dichotomies, see Lloyd (1973). Whereas Plato felt that at least some women could be educated to the level of men, Aristotle believed the inequality of the sexes was permanent and biologically ordained (Ghougassian, 1977). Aristotle felt that "the female state is . . . as it were a deformity" and therefore education would refine and thus heighten her natural depravity (O'Faolain & Martines, 1973, p. 182). This negative attitude toward women, and their intellect, had softened somewhat by the first century A.D. Plutarch, in a letter to a newly married couple, recommended instruction in mathematics, philosophy, and astronomy for women. This instruction, however, was limited to developing moral virtue, not an independent mind (Agonito, 1977).

Ghougassian (1977) presented a comprehensive review of Hellenic culture and thought as expressed by the Greek and Roman philosophers, and its impact on present day Judeo-Christian thought. In his review, Ghougassian draws a comparative analysis between the Hellenic philosophers' views on women and those of early Jewish and Christian thinkers. He stated as a two-fold thesis

1. that western attitudes toward women derive fundamentally and foremost from Hellenic heritage
2. that exponents of the Old or New Testament (Judeo-Christianity) accepted with no contestation the Hellenics' philosophy of woman. They compromised the golden rule, brotherly love among all peoples, with Hellenic misogynism--a blatant contradiction--and paraphrased the Bible's views on women with the aid of Hellenic philosophy (p. 141).

Proof of Ghougassian's charges can be found by reading the disciple Paul's charges to the Corinthians

> Now I want you to realize that the head of every man is Christ, and the head of the woman is man, and the head of Christ is God. Every man who prays or prophesies with his head covered dishonors his head. And every woman who prays or prophesies with her head uncovered dishonors her head--it is just as though her head were shaved. . . . A man ought not to cover his head, since he is the image and glory of God; but the woman is the glory of man. For man did not come from woman, but woman from man; neither was man created for woman, but woman for man. For this reason, and because of the angels, the woman ought to have a sign of authority on her head. (I Corinthians 11:3-10, Holy Bible, New International Version, 1978, p. 1230)

Agostino (1977) reported there was evidence that, consistent with Jesus' example, women played an important part in the new church. Paul objected to this new turn and his "reactionary efforts in the matter of women succeeded in setting the tone for thinking about women that would be continually reinforced in the intellectual and practical tradition in the West for the next two thousand years" (p. 68). Both Augustine (circa 400 A.D.) and Thomas Aquinas (circa 1270 A.D.) picked up and carried on the torch of female dependence and inferiority, relying heavily on the Aristotelian idea that female inferiority was a natural state, owing to man's greater rationality.

This historical theme--of female heads being inferior, imperfect, even defective and thus requiring that males become the heads of females, literally and figuratively--is enlarged upon by Stannard (1977). Outlining evidence gathered by Onians (see p. 50), Stannard asserted that the physiological theories of Paul's time reinforced his belief that God had given women defective heads. In early civilizations men's heads were believed to contain the source of life and the ability to transmit the soul. Stannard stated

> What we call brains was regarded as congealed seed (semen) that traveled down the body inside the spinal column and collected in the testicles where it waited to be discharged by the penis. . . . Since women had neither the casks nor the spiggot for drawing off the head's life matter, it was logical to conclude that women had no seed=life in their heads, which was why Aristotle held that a child's soul derived only from the father. (p. 50)

Investigations Into Cognition

The first systematic treatment of male/female differences in cognition appeared in the literature, according to Shields (1975), in 1575. Juan Huarte (cited in Shields) attributed sex differences in cognition to the bodily humors. Humors, the body fluids or juices, were once regarded as responsible for one's health and disposition. This idea has been popular since ancient Greece. The male/female differentiation was along the dichotomous lines of heat and dryness for the male, and moisture and coolness for the female, and these notions were intricately woven into reproductive ability and intelligence.

Use of the humoral theory to explain male/female differences in cognition was accepted through the 17th century. It was to be replaced by more sophisticated and scientific theories and practices in the 18th and 19th centuries. Although new in method of approach, these theories were old regarding perpetuation of the bias towards proving the inferiority of female cognition. Instead of concentrating on the bodily fluids, scientific methodology now turned to the measurement of skull size, brain size and weight, and bumps on the surface of the skull. Philosophers and writers had formulated the hypothesis of inferior female intellect. To quote Hegel, "Women are certainly capable of learning, but they are not made for the higher forms of science" (O'Faolain & Martines, 1973, p. 290). Additionally, Kant and Schopenhauer had proven, at least to their own satisfactions, the justice of woman's subordinate social position (Shields, 1975, p. 740). It was left to the scientists, particularly the phrenologists and craniometricians, to find the necessary physiological evidence.

Phrenology and Craniometry

Phrenology, which has since fallen into disrepute, was introduced by Franz Joseph Gall in the early 1800's. Calling it "crainoscopy," Gall believed that the various mental and moral processes were seated in specific areas of the brain's surface, and differences could be detected by external examination of the skull. Gall was convinced he could discriminate between male and female brains from gross anatomical observations of adult animals of any species (Shields, 1975). Although no longer a valid method, phrenology laid the basis for comparing the appearance of all or part of the brain for physical evidence of quality of function. Phrenology and craniometry became the most popular means of providing proof of inferior female mentality.

Paul Broca, an eminent and scholarly French doctor, devoted much of his life to the study of the brain. A part of the brain which is responsible for certain types of speech and an aphasic condition both bear his name. Under Broca, craniometry--the measurement of the skull and its contents--developed in late 19th century Europe as a rigorous and respectable science. According to Gould (1981), Broca was an exemplary scientist; no one has ever surpassed him in meticulous care and accuracy of measurement. However, Gould felt that Broca and others before and since, were trapped by their own rhetoric. "They believed in their own objectivity, and failed to discern the prejudice that leads them to one interpretation among many consistent with their numbers" (p. 74). Gould alleged that Broca used numbers to illustrate a priori conclusions, not to generate new theories. Broca stated in 1861

> We might ask if the small size of the female brain depends exclusively upon the small size of her body. Tiedemann has proposed this explanation. But we must not forget that women are, on the average, a little less intelligent than men, a difference which we should not exaggerate but which is, nonetheless, real. We are therefore permitted to suppose that the relatively small size of the female brain depends in part upon her physical inferiority and in part upon her intellectual inferiority. (Gould, 1981, p. 104)
>
> In general, the brain is larger in mature adults than in the elderly, in men than in women, in eminent men than in men of mediocre talent, in superior races than in inferior races. . . . Other things equal, there is a remarkable relationship between the development of intelligence and the volume of the brain. (Gould, 1981, p. 83)

Accordingly, the smaller head and brain size of women as compared to men was taken as prima facie evidence of anatomical indicators for women's functional inferiority. It was believed that more brain necessarily meant better brain (Gelman, 1981; Gould, 1981; Hubbard & Lowe, 1979). However, since males were both taller and heavier than females on the average, what Hubbard and Lowe termed the "elephant problem" surfaced. "If absolute size of the cranium were taken as the criterion, then elephants and whales ought to be more intelligent than humans" (p. 16). When adjustments were made for males' greater height and weight, it tended to offset their brain size advantage.

So the search was on to find a suitable relevant measure. If the ratio of brain surface to body surface was computed, then the evidence favored men. But, as pointed out by Shields (1975), women possess a proportionately larger brain than men if the ratio of brain weight to body weight is considered. "Once the superiority of women was suggested by the brain to body weight studies, scientists moved quickly to try other criteria which might demonstrate the 'correct' relationship of the sexes" (Hubbard & Lowe, 1979, p. 16). A host of indices were used, including brain weight to body height, brain to thigh bone weight, and brain to spinal marrow ratios. No appropriate measure was to be found, thus there was no agreed upon legitimate solution to the problem. Even on those measures which showed a male advantage, the relationship of the index used to intelligence was far from satisfactory.

Using data by Broca which had compared prehistoric and modern skulls of males and females, Le Bon, in 1879, launched what Gould (1981) described as "the most vicious attack upon women in modern scientific literature." Le Bon wrote

> In the most intelligent races, as among the Parisians, there are a large number of women whose brains are closer in size to those of gorillas than to the most developed male brains. This inferiority is so obvious that no one can contest it for a moment; only its degree is worth discussion. All psychologists who have studied the intelligence of women, as well as poets and novelists, recognize today that they represent the most inferior forms of human evolution and that they are closer to children and savages than to adult, civilized man. They excel in fickleness, inconstancy, absence of thought and logic, and incapacity to reason. Without doubt, there exist some distinguished women, very superior to the average man, but they are as exceptional as the birth of any monstrosity, as for example, of a gorilla with two heads; consequently, we may neglect them entirely. (Gould, 1981, p. 104)

As an interesting aside to this study, Gould (1981) reported on the fascination that scientists of the 19th century had with brain size and its relationship to eminence. "The dissection of dead colleagues became something of a cottage industry among nineteenth-century craniometricians" (p. 92). Wagers were even made between leading anthropologists as to whom had the larger brain. Gould's account of how Broca explained away the small brains of some eminent men makes humorous and interesting reading. Broca himself, it turns out, had a brain just a bit above average in size, and Gall's was well below average. The data for Le Bon's brain were not available.

Gould (1981), a paleontologist who considers himself a positive debunker, re-analyzed Broca's data using multiple regression techniques that would allow for simultaneous assessment of the influence of many factors. "In short, Broca's data do not permit any confident claim that men have bigger brains than women" (p. 107). It is also interesting to note that, almost without exception, the 19th century researchers knew, before they took their measurements, the sex of the person whose brain or skull was to be measured (Gould, 1981; Mall, 1909; Shields 1975).

Specific Brain Sites

In the mid and late 19th century, interest was also shown in specific areas of the brain. When the frontal lobe was believed to be the seat of intellect, the craniologists reported finding larger and more well developed frontal lobes in males than in females (Gould, 1981). At the turn of the twentieth century, the parietal lobes came to be regarded as the dwelling place of superior intellect. It was then that neuroanatomists began finding the parietal region smaller in females and larger in males. Prior to this time the reverse was believed to be true (Gelman, 1981; Shields, 1975).

Soon after the turn of the twentieth century, an earlier debunker than Gould reported on a reanalysis of past research results, especially concerning the frontal lobe. Mall (1909), an American anatomist at Johns Hopkins University, reviewed and reassessed the actual data from studies dating back to 1854. Mall was concerned with the conclusions which had been drawn about women and non-white races in those studies. In general, Mall believed that the differences found were largely due to the "personal equation of the investigator" (p. 6). In a number of experiments on various cerebral lobes and the corpus callosum, Mall attempted to duplicate exactly the procedures of earlier researchers, the only difference being that he did not know beforehand the race or sex of the person from whom the brain was taken. Mall concluded

> Each claim for specific differences fails when carefully tested, and the general claim that the brain of woman type is foetal or of simian type is largely an opinion without any scientific foundation [p. 27] . . . portions of the brain vary greatly in different brains and a very large number of records must be obtained before the norm will be found. For the present the crudeness of our method will not permit us to determine anatomical characters due to race, sex, or genius and which if they exist are completely masked by the large numbers of marked individual variations. (p. 32)

Wooley (1910), a psychological researcher, considered Mall's paper the most important single contribution to knowledge concerning the mental characteristics of sex. In a review of the literature on the psychology of sex, Wooley stated

> There is perhaps no field aspiring to be scientific where flagrant personal bias, logic martyred in the cause of supporting a prejudice, unfounded assertions, and even sentimental rot and drivel, have run riot to such an extent as here. (p. 340)

Impact of Investigations

The works of the phrenologists and craniometricians of the past were not just a plaything for scientists. The subject of male/female differences in brain and skull size was not confined to technical journals. The conclusions found their way into popular magazines and newspapers. Commenting on the conclusions being drawn, Gould (1981) stated "once entrenched, they often embarked on a life of their own, endlessly copied from secondary source to secondary source, refractory to disproof because no one examined the fragility of primary documentation" (p. 82). In certain ways, history might be repeating itself 100 years later. Attitudes are developing about male/female characteristics of the brain, attitudes which are fed by the popular press of this more sophisticated time. Unless care is taken to examine the evidence, we stand in danger of inventing a 20th century version of a very old theme about heads and brains. Instead of looking at size and weight of brains to reinforce values, we could be substituting "male" and "female" hemispheres, with their attending values.

Left/Right Dichotomies and the Sexes

The idea of bipolarity between males and females, the notion of masculinity and femininity as opposite poles of experiences, is found in the history and the mythology of many cultures. "The history of human thought suggests that whenever two apparently opposing principles were observed, they were linked to maleness and femaleness" (Colwill & Lips, 1978, p. 127). The bipolar assignment of function of the two cerebral hemispheres has also carried suggestions of division of function along gender lines, with the implication of male/female cognitive differences particularly regarding verbal and visual/spatial skills. Star (1979a) felt the "popularizations of current research on brain asymmetry rely heavily upon cultural stereotypes about left and right, mixed with Eastern and Western myths about yin/yang and left/right" (p. 61).

Psychologist Robert Ornstein is credited by both Star (1979a) and Russell (1979) as being a leading popularizer of the current research on brain asymmetry. Star felt that Ornstein's emphasis on old Buddhist literature when discussing left and right brain functions "condones and reifies many traditional stereotypes of 'masculine' and 'feminine' and extends their use into 'scientific' research" (p. 61). The assignment of females to strong left-brain cognitive abilities and males to strong right-brain cognitive abilities also carries with it an implicit value attachment which is rooted in historical and cross/cultural ideas of the qualities of right and left.

Domhoff (1969) noted a near-universal connotative meaning of left and right and demonstrated it through studies in anthropology, history, dreams, case histories, and psychological tests. Domhoff believed the basic question was the origin of the "Right-good, Left-bad dichotomy" (p. 587). Lloyd (1973) traced back symbolic associations for right and left to the ancient Greeks in the fifth and fourth centuries B.C. The associations dealt with values assigned to the right or left sides of the body. The right was considered superior and was associated with lucky, light, safety, and males; the left was associated with unlucky, darkness, death, and females.

This ancient, cross-cultural theme of Right/Good/Male and Left/Bad/Female is developed and detailed by both Lloyd and Domhoff.

Both reviewers agreed that the right was not invariably the sacred side, as evidenced by values attached to the right and left sides of the body by the Zunis and the ancient Chinese. "This reversal of the usual associations indicates, to my mind, the part played by social, rather than purely physiological, factors in determining the attitude to right and left" (Lloyd, 1973, p. 168).

Domhoff (1969, p. 588) described a recently translated summary of historical and anthropological findings on left and right which yielded the following evidence of cross-cultural associations with left and right. Australian aborigines hold the "male" stick in the right hand and the "female" stick in the left hand. American Indian sign language uses the left hand for such concepts as "weak" and "cowardly." The Maori of New Zealand "associate the Left with the bad, the dark, the profane, the feminine, the night, homosexuality, and death, which the polar opposites of these concepts are associated with the Right" (p. 588). Bedouin Arabs believe women are bad and must live on the left side of the tent; men are good, and thus live on the right side on the tent.

Domhoff (1969) also described how psychoanalysis has used similar connotations for left and right, particularly in dream interpretation and analysis of symptoms. The left side or hand, regarded as the weaker feminine side, meant doing things the wrong way. Freud, in a letter to a confidant, said the suggestion that he (Freud) was partially lefthanded suggested to Freud the meaning of "guilty" (Domhoff, 1969, p. 590). Domhoff believed the evidence he reviewed suggested that not only have many nonliterate peoples, our ancestors, and psychoanalytic patients attributed similar connotations to the left and the right, but also that it is a dichotomy which is present in the thinking of a majority of healthy, well-educated Americans. Domhoff presented, as evidence of his claim, the results of the Osgood Semantic Differential Test, given in the late 1950's to a group of American college freshmen and sophomores who did not know the purpose of the study. The Osgood test measures the meaning of a word, concept, or image by having the person rate it on a series of scales of word opposites. The concepts Left and Right were rated on polarizations which had been suggested by historical and anthropological records: good/bad, female/male, strong/weak, etc. Domhoff stated

> The Left was characterized as bad, dark, profane, female, unclean, night, west, curved, limp, homosexual, weak, mysterious, low, ugly, black, incorrect and death, while the Right meant just the opposite--good, light, sacred, male, clean, day, east, straight, erect, heterosexual, strong, commonplace, high, beautiful, white, correct and life. Further, our study of school children from the third through the ninth grades showed similar results for the Right on the eight semantic differential scales utilized, although it was not until the sixth grade that the Left became extremely negative on most dimensions. (p. 590-591)

Lloyd (1973) addressed the tendency to identify certain pairs of opposites with the sacred and the profane and stated ". . . we find that such pairs as day/night, right/left, and male/female are often themselves correlated or identified, even where there is no manifest connection between them" (p. 169). Star (1979b) carried this form of thinking a step further and discussed its illogical and contradictory nature.

> The equation of the female with the left side of the body, and thus the right side of the brain, is a confusing mythological underpinning from the point of view of subsequent research, which began to identify the left cerebral hemisphere with verbal ability, at which females seem to be better than males. None of the research I have read has directly confronted this contradiction; rather, gender-marked words, such as "masculine" have permeated the field and contributed unnecessary confusion to it. (p. 118)

Current research on brain asymmetry reports hemispheric assignment of function for verbal and visual/spatial skills, in addition to gender assignment regarding the relative strengths of those skills. Additionally, there appears to be subtle assignment of value placed on the verbal and visual/spatial skills. Gornick (1982) discussed the current trend toward redefining "verbal" and "spatial" as a result of recent findings in brain research and the attending contradictions. The terms "verbal" and "visual/spatial" have fallen into the trap of dichotomization. The attendant value currently placed on each skill might very well be a result of the undercurrent of centuries of thinking regarding differences in cognition between males and females, as well as the conceptual associations that have historically been made regarding values of left and right.

The present study can do nothing to change the impact of centuries of thinking regarding male/female differences in cognition, but can suggest that the reader be aware of the existence of this potential underlying influence. Rather, this study researches the nature and strength of male/female differences found in standarized tests which investigate verbal and visual/spatial skills. Additionally, this study considers the nature of the tests themselves and the confounding variables which could influence the test results and the interpretation of those results. The present chapter has dealt with historical and dichotomous thinking regarding males and females because current theories, research findings and generalizations about cognition cannot be divorced from past forces which may have a substantial impact and bearing. There has, as yet, been no way to statistically consider those forces as co-variates when considering the evidence, or to incorporate those forces into a multiple regression model. However, it does seem germane to the present topic of male/female cognitive differences to consider those forces as omnipresent and perhaps even omnipotent.

CHAPTER THREE
LIMITATIONS OF RESEARCH CONCERNING MALE/FEMALE COGNITION

"The body of knowledge that we call the psychology of sex differences is only as strong as the theory and research that comprise it" (Lips & Colwill, 1978, p. 3). That statement typifies the growing concerns regarding the validity of research into male/female cognitive differences. Investigators who are seriously interested in assessing those cognitive differences have described the problems attendant to this type of research. Each author has emphasized those limitations to the research which he/she felt had the greatest impact on the worthiness of the studies under consideration. There occurs, however, a reiteration in the literature of certain themes concerning research limitations. So the necessity for some type of classification scheme becomes apparent, in order to discuss the concerns reported. Sherman (1978) presented a very precise and broad-scoped analysis of the limitations of research into male/female cognitive differences. This chapter uses Sherman's model of organization as an outline, with additions and expansions included from the several other reviewers covered in this study.

The analysis and synthesis of research limitation presented in this chapter could potentially set the criteria against which studies in the field of male/female cognitive differences can be compared. To make a practical, unbiased judgment as to the importance of studies cited in the journals and popular books, the pitfalls and problems which surround and act upon studies in this field need to be recognized. Otherwise, it is possible to fall into the "Emperor's New Clothes" line of reasoning, where statements are readily accepted as facts. This almost blind acceptance occurs because (1) it is easier to accept what others say than to prove it out, or (2) it is popularly willed to be as stated because the reality carries its own consequences. No straight-thinking peasant would have proclaimed that the king was indeed naked, or he/she might have come up headless.

Challenging well-credentialed or well-established writers in the field of male/female cognitive differences can also have its own head-rolling repercussions. Block (1976a), in an extensive critical review of one of the most popular works in the field of sex differences, quoted Samuel Pinneau: "The role of critic is a thankless but necessary one, especially where the material criticized fosters a widely popular 'will to believe'" (p. 522).

Criticism of the research has been regarded as necessary by most of the current investigators of male/female differences, in order to avoid misleading interpretations and faulty conclusions. This study presents the major criticisms encountered in the literature. A basic assumption is that the majority of readers of this study have had a basic, but limited exposure to statistical analysis. Therefore, where it is felt to be necessary, definitions and explanations of statistical terms are used that may be of little interest to the more statistically-oriented reader. The discussion on limitations of the research will be subdivided into (a) conceptual, (b) measurement and design and (c) statistical considerations. The subheadings under this classification system may be arbitrary in some instances, but the scheme facilitates the purposes of this study.

Conceptual Problems

The Null Hypothesis

The null hypothesis, probably the most frequently used approach in scientific and psychological research, states that there are no differences betweeen two conditions or two groups. Additionally, the investigator, if so desired, can state a research hypothesis in which the direction of the expected differences will be predicted a priori (up-front). These two hypotheses are bipolar, producing an either/or situation which concentrates on differences, not on both similarities and differences. Generally, the researcher attempts to reject the null hypothesis; he/she attempts to prove that differences do exist between the two conditions under consideration. Thus the use of the null hypothesis approach generates an undue emphasis on the differences between groups to the exclusion of seeing the similarities between them.

This situation has developed out of what Wittig and Petersen (1979) term "prejudice against the null hypothesis" (p. 6). They feel there is a requirement in most publications that an article show some positive results. Although null findings can result from a variety of factors not related to any potential differences between the groups, the net effect is that studies showing no differences are not given anywhere near equal publishing time with studies showing a difference. Sherman (1978) mentioned "philosophical underpinnings" of the null hypothesis approach which she believed "clearly have detrimental effects in the 'sex differences' area" (p. 19). If the researcher does not find a large enough _t_ and _F_ statistic to be able to reject the null hypothesis of no differences, does that mean the hypothesis is true? Would it indicate that there are no differences between the sexes?

Sherman (1978) discussed the social consequences of committing Type I and Type II errors. A Type I error implies that the null hypothesis was true, at least statistically speaking, but was rejected as not being true. In other words, differences were found, when in fact differences should not have been shown. The reverse, a Type II error implies that the null hypothesis of no differences has been accepted as being true, when in fact it is not true. Differences were not shown when they should have been. Sherman contended that the risk of making a Type II error, of accepting a false hypothesis of no cognitive differences between the sexes, is not considered a serious error. In terms of negative social consequences, Sherman felt that the risk of a Type I error was far more serious. In other words, to find differences when they may not exist at all is much more serious than not finding differences that truly do exist.

Block (1976b) felt the null hypothesis approach contained inferential inadequacies and had a tendency to lead to the misinterpretation of the data. Block quoted Cronbach (1975) as recommending that "the time has come to exorcise the null hypothesis . . . the cannon of parsimony has been misinterpreted, has led us into the habit of accepting Type II error at every turn, for the sake of holding Type I errors in check" (p. 289). Lloyd (1976), as well as Petersen and Wittig (1979), discussed the inadequacies of the null hypothesis under the heading of methodological problems, and rightly so. However, the basic conceptual problem presented by use of the null is the most important area of discussion at present. Star (1979b) stated the situation quite eloquently and forcefully

> A more fundamental theoretical problem with sex differences research is that its basic orientation is toward differences. By searching these out it magnifies them and often obscures the fact that they may be the conveniently stereotyped extremes of broadly overlapping potentialities and functions. Research on sex differences therefore has often served to further stereotype and oppress women. The unstated biases that consistently inform this research are self-fulfilling: researchers find what they expect, and interpret their findings in traditional ways. Pseudo-scientific "proof" marching under the banner of "science" only strengthens old stereotypes. (p. 63).

Naturalistic Fallacy and Evolutionary Determinism

Sherman (1978) felt that a particular line of reasoning ran rampant in studies of "sex-related differences." Sherman stated that two assumptions were made by some writers: (1) that what is, must be, and what was, should and shall be, and (2) finding a partial biological basis for a "sex-related difference" means that this difference is immutable and/or desirable (p. 19). Reasoning along the same lines, Petersen and Wittig (1979) stated

> To say that a sex-related difference is biological is not an informative statement. We must describe the process by which biological characteristic differentiating the sexes (sex chromosomes, sex hormones, anatomical differences) might influence academic achievement. . . . In our society we tend to interpret behaviors thought to differentiate the sexes as inevitable ones. Many observe "what is" regarding sex differences and assume that these differences "must be." There are very few behaviors that inevitably differentiate males from females, and those we can think of relate to anatomical sex differences. (p. 5)

Archer (1976) found the idea of evolutionary determinism open to conceptual and practical objections, and pressed instead for an interactive model. Hubbard and Lowe (1979) devoted an entire book to the examination of the impact of genes on gender research; the chapter by Salzman, a physics researcher, concluded

> The theoretical and practical difficulties of establishing the "biological" determinants of behavior in humans within the normal range, appear to be insurmountable at this time. Now and for the forseeable future, one should be extremely skeptical of studies that purport to establish a biological basis for group differences in complex human social behaviors that lie within the normal range. (p. 859)

Extrapolations from Animal Data

Sherman (1978) cautioned that since inferences cannot be drawn from one animal species to another because of so much variation between nonhuman species, no conclusions should be made about humans solely on the basis of animal data. Sherman felt those kinds of inferences might lead the nonprofessional readers to erroneous conclusions. However, in reality it is a frequent technique of researchers into human behavior to use animals as subjects. One fallout problem is that results imply the studies were carried out on humans, particularly when reported in popular books (see Sherman, 1978). Addressing this problem, Lips and Colwill (1978) stated

> We learn much about lower animals from laboratory animal research, but it is only too tempting to suppose we are learning the same thing about humans. . . . At best, we are arguing by analogy. At worst, our results may not even apply to animals of the same species raised in the wild. (p. 8)

In a concurring opinion, Archer (1976) related that many current theories about humans are based on work with animals. Archer felt that correspondence between the animal and human tests is not satisfactory. The measures used, according to Archer, for animals and for humans are rather different, but are lumped under one behavior category. As an example, aggression studied in animals is not a comparable characteristic to agression studied in humans. Archer summarized

> The theories based on evidence of this type are, therefore, best viewed as useful in stimulating research on possible biological factors involved in human sex differences, rather than providing any complete or correct answers in the form they are presented. (p. 250)

Generalizations from Non-normal Subjects

Hardyck and Haapanen (1979) questioned the validity of data from split-brain patients being used to interpret normal functioning. A great deal of current information on lateralization of cerebral function came from the systematic study of nine severe epileptic patients who had undergone dramatic surgical intervention. In those epileptic patients, the majority of the fibers of the corpus callosum (the structure connecting the two hemispheres of the brain) were severed. The evidence gathered by Sperry and his students indicated that the epileptic patients had striking hemisphere differences; these findings led to the development of the concept of separate functioning of the cerebral hemispheres.

Hardyck and Haapanen felt the possibility of cortical reorganization of function prior to surgical intervention was high for Sperry's epileptic patients. In six of the nine patients, seizures were present from birth or appeared in early childhood. Cortical reorganization following cerebral damage is known to occur in early childhood, and may be possible until approximately age 13. In their review of the literature on the subject, Hardyck and Haapanen acknowledged the existence of a convincing argument and stated

> Hemisphere differences as assessed in the commissurotomy patients are inappropriate models of functioning for the normal human, since the possibility of drastic cortical reorganization cannot be eliminated . . . [additionally] It is impossible to know the extent of trauma or damage caused by the surgery. . . . Given these limitations, its seems

> appropriate to exercise caution in generalizing from commissurotomized human to intact human. In fact, the safest course of action might be to conclude that data on commissurotomy patients is valid only for those patients (p. 223).

Cohen's (1977) evidence agreed with that presented by Hardyck and Haapanen. Cohen gave additional reasons why the capacities of the disconnected hemispheres may not give an accurate indication of lateralization of function in the normal intact brain: (a) the possibility that some information can still be transmitted from one hemisphere to the other via remaining pathways in the brain cannot be entirely ruled out, (b) since the disconnected hemispheres are not subject to the mutual facilitation and inhibition that occurs in the intact brain, their functioning must necessarily be different, and (c) the ability of the epileptic patients, after years of testing, to "cross-cue" between hemispheres, bypassing the severed collosal route, and transmit information by bodily gestures and orientating responses has been noted by most researchers (p. 193-194).

In spite of the limitations inherent in generalizing from split-brain or brain-damaged subjects, many researchers, including those investigating male/female cognitive differences, continue to make that conceptual leap. For examples, see Lansdell (1962), McGlone (1977, 1978, 1980) and McGlone and Kertesz (1973).

Duality and Bipolarity

One of the favorite pastimes of our society is to address situations in terms of bipolarity and dualities. We feel more comfortable when we can arbitrarily divide people, abilities, and anything else, into two groups, two dichotomous boxes. This leads into what Sherman (1978) descibed as the "Yin-Yang fallacy" (p. 20), where groups are placed in opposite categories. A value is also attached to the two categories. Lists of dichotomies regarding male/female attributes are pervasive in the literature; this subject was reviewed in Chapter Two.

Sherman proposed that the "dualistic, bipolar theory induced a certain specious comfort in the reader who is often not sufficiently critical to challenge the surface validity of the concepts involved" (p. 20). Fairweather (1976), in describing the historical psychological differentiation of the sexes, felt that researchers, male and female alike, were subtly distilling a dichotomy when they reported results of experiments (p. 232). Fairweather described the dichotomies as being characterized variously as modal, emotional-hormonal, emotional-cerebral, but above all, biological. "But analogies and likewise dichotomies are dangerous. What had before been a possibility at best slenderly evidenced, was widely taken for fact; and 'fact' hardened into a 'biological' dogma" (Fairweather, 1976, p. 233). Lips and Colwill (1978) stated this idea another way

> The history of human thought suggests that whenever two apparently opposing principles were observed, they were linked to maleness and femaleness. . . . These dualities were not originally associated with sex but the association grew up through the attempts of men to rationalize their advantaged position by defining themselves as the One and women as the Other. (p. 127)

Faulty Cross-sex Inferences

Female subjects are not as often studied as male subjects (Sherman 1978; Prescott, 1978). Sherman believed this was the result of two assumptions: (1) what applies to males applies to females, or

(2) whatever applies to males, the opposite applies to females. Sherman believed that in fact, neither assumption was necessarily true. Maccoby and Jacklin (1974) reported that researchers make faulty inferences about "between" sex differences from "within" sex data. However, Sherman believed that Maccoby and Jacklin fell into a similar error when they criticized Sherman's "bent twig" hypothesis. This hypothesis, which is based on the law of primacy, holds that females develop a preference for a verbal problem solving approach; the hypothesis is discussed in more detail in Chapter Four.

Pitfalls of Age-related Inferences

To draw an inference about differences between the sexes based on the age of subjects can lead to inaccurate conclusions. One cannot clearly attribute differences that occur later in childhood to socialization. Nor can one attribute all the changes occurring at puberty to the biological changes of puberty. Changes in sex roles may be cued to biological changes; the problem emerges when one tries to find a simple, infallible causal guide to reasons for differences between the sexes.

Statistical versus Practical Significance

In order for a research study to reach what is called statistical significance, the computed t or F statistic calculated from the data must reach a certain level. This obtained level is compared against the critical t and F statistic in existing statistical tables. If the computed figure meets or exceeds the critical figure, then the results are considered significant. Generally a researcher states, up-front, the probability level at which the results will be considered significant. The usual probability level selected is 0.05. This means that if the experiment were to be repeated 100 times, there is a 5% or less probability that those same results would occur by chance. At the 0.01 or 0.001 levels of significance, the researcher is allowing even less probability for chance results. These latter levels of significance are harder to obtain; they require more powerful results.

Sample size is a very important consideration in determining statistical significance. The sample size must be large enough to detect any existing differences. For example, to show that two groups differ in IQ by at least four points, at the 0.05 level of significance each group would require at least 416 subjects. However, extremely large samples may show a statistical significance which has no practical significance. Petersen and Wittig (1979) gave the following example: in a sample of 100,000 males and 100,000 females, a difference in IQ score of about .02 is significant at the 0.001 level. One must surely question the practical significance of this result. Bear in mind, however, that those results could possibly be reported in a journal, popular book or magazine as, for example, "Dr. Cooke found a significant difference in IQ between the sexes." Sherman (1978) felt that small, but valid, differences may be of theoretical interest, but that many "apparently demonstrated sex-related differences are so small that they are of essentially no practical importance" (p. 23). Suggestions for more appropriate statistics will be covered in the last section of this chapter.

Problems of Measurement and Design

Bias in Measures

Sherman (1978) asked a very appropriate question concerning measurement bias: what does constitute a cognitive difference between males and females? Studies showing a difference usually report a mean score comparison between the two groups on some test score. Sherman believed the following factors can bias the results: (1) content and wording can have negative results for females in their performance on tests of cognitive differences, and (2) sex of examiner does not affect males, but females score higher with a female examiner. (See Sherman, p. 24, for cited references to support those contentions.)

The problem also exists of an unwitting selection, by test constuctors, of test items which maximize sex differences. According to Kipnis (1979) the normative data obtained by Wechsler in 1939 for his Wechsler-Bellevue IQ adult intelligence test showed slight but positive differences in favor of females at all ages. "Wechsler, in fact, remarked that the consistency of the differences had led him to the belief that it might be possible to demonstrate a measurable superiority of women over men in general intelligence" (Kipnis, p. 100). As an interesting aside, when that test was restandardized in 1955, the revised version showed slight differences in favor of males on some of the same subscales that had shown sex differences in favor of females in the 1939 version (Kipnis, p. 100).

Sherman (1978) felt the problem of biased test items could lead the test developer to mistake artifact for reality. Having created a test which unwittingly maximizes male/female differences, the developer might be tempted to believe that strong male/female differences do exist. The fact that the test facilitated the appearance of differences goes unnoticed. In his comments on test bias, Dwyer (1979) described how societal biases can affect the measurement of cognitive functioning. Since test constructors are reared on the prevailing social values, the item content and format of standardized test can become vehicles for the perpetuation of such biases.

Measures Used

In studies which have reported a male/female difference in either verbal or visual/spatial skills using normal subjects, two frequently used measures are dichotic listening tasks and tachistoscopically presented tasks. The following are definitions of those measures:

1. dichotic listening--differing auditory stimuli are presented simultaneously to the right and left ears. Contralateral (opposite side) nerve fibers take functional precedence over ipsilateral (same side) nerve fibers when both are simultaneously stimulated. It is expected that when verbal stimuli are used, there should be a right ear advantage, since fibers from the right ear take precedence in reaching the left hemisphere where language functions have been demonstrated to be located.
2. tachistoscopic presentations--the subject is required to focus on a reference point displayed in a tachistoscope or on a projection screen. When the subject fixates the reference point, stimulus projected to the right or left of the fixation point for a period not to exceed 150 milliseconds will be registered on nerve paths

leading to only one hemisphere, depending on placement of the stimulus.

Regarding dichotic listening measures, Blumstein, Goodglass and Tartter (1975) and Bryden (1975) reported problems of reliability of measurement with that technique. Teng (1981) considered dichotic ear difference a poor index for functional asymmetry between the cerebral hemispheres, not only because of the low retest reliability of the measures, but also because dichotic ear differences reflect both an ability asymmetry between the two hemispheres and an input asymmetry. Hardyck, Tzeng and Wang (1978) suggested that hemispheric differences in verbal ability may be differences in memory rather than thinking.

Methodological problems with tachistoscopic measures were discussed by White (1969) and Hardyck and Haapanen (1979). White contended the relationship between dominance and visual stimulation has not been well demonstrated, and that the nature of the nonverbal visual stimuli as "nonverbal" is questionable. White held that hemispheric differences in visual perception was a composite of many factors: (a) the type of stimulus presentation, unilateral or bilateral, (b) the amount, nature, and spacing of the stimulus-information elements, (c) the intensity at which the information is shown, (d) the order in which the information is reported, (e) the viewing condition employed, and the ocular dominance of the subjects and (f) the handedness and laterlization of the subjects.

Hardyck and Haapanen (1979) reached the following conclusions regarding tachistoscopic measures:

1. Right/left brain differences are not detectable when new information is presented on every trial or measure. Studies using a

small number of stimuli and a large number of repetitions have no analogue in real life speech, reading, or communication acts.

2. There may exist, within a hemisphere, a differential memory for language and visual/spatial materials.

3. Some areas common to both hemispheres carry out the processing tasks and call information from memory as needed. This processing system is much more sophisticated than a "left brain for one kind of thinking, a right brain for another kind" model (p. 228).

Hardyck and Haapanen believe the methodological evaluations of hemispheric difference experiments have tended to focus on the experimental methodology per se, and not on the larger evaluative framework. They stated

> The questions remain as to (a) whether these observed differences in hemisphere function exist in a context outside of the laboratory procedures used to study them, and (b) whether these results have any implications for educational practice. [p. 225] . . . We should ask for more evidence that these differences really exist outside a narrow experimental context unrepresentative of either the educational process or the course of daily life. (p. 229)

Achievement versus Ability Tests

When an "achievement" is measured, it is generally believed the learning itself is being measured. The terms "aptitude" and "ability" generally refer to inherited traits. In drawing conclusions about test results in cognitive studies, a confusion has emerged concerning what each type of test measures and what can be concluded from the results.

Sherman (1978) discussed the two problems that have developed: (1) achievement tests have been used that have such generality as to be very similar to ability tests, and (2) the tests and terms have been used in such ways as to increase social risk to certain groups:

specifically, "using ability tests as the only pre-post measures of intervention programs, and finding sex-related differences on achievement tests between groups unequal in mathematics background and from this implying the sexes are different in mathematics ability" (p. 26). Because experiential factors strongly affect performance on ability and aptitude tests, Sherman cautioned one cannot assume that group differences reflect inborn, genetic differences. "This fact, acknowledged in the abstract, is forgotten in concrete interpretation of results" (p. 27).

Selection Factors

Another major source of questionable results which suggests differences between the sexes is the matter of sample selection. Wittig and Petersen (1979) believed that high school studies into sex-related differences in cognitive functioning were actually comparing two dissimilar groups. Since males are more likely than females to drop out of school, the studies were comparing a more heterogeneous female group with a more homogeneous, and perhaps more intellectually motivated male group. Sherman (1978) stated that many colleges have had differential admission standards, where females had to have better records than males to be admitted. If this is true, then studies done at those colleges would be comparing a more select group of females against a less select group of males. An interesting point raised by Sherman was the hypothesis that any live male population is more select than the female population. According to Sherman

> One hundred and twenty males are conceived for every one hundred females, and there are one hundred and six male live births for every one hundred females. Males die off at faster rates than females at every decade of life. In

> middle age there are about equal numbers of the two sexes, while there are many more females than males in old age. If the more intelligent samples of the genotype are more likely to survive, every comparison of a male and female group involves the comparison of a more select male group with a less select female group. (p. 27)

One must be careful to substantiate the "if" clause in the above statement before one accepts it as a logical argument.

Sherman (1978) believed that male/female differences are best studied on samples that are matched for prior relevant experience. Hyde (1981) disagreed, on the basis that Sherman's approach may involve different percentages of the male and female populations, and different cutoff points in their distributions. "Essentially, it confuses research on the existence of a gender difference with research on the cause of it" (Hyde, 1981, p. 899). Hyde reviewed the sampling problems of the studies analyzed by Maccoby and Jacklin (1974). Hyde argued "if one is to assess the existence and magnitude of cognitive gender differences, careful attention must be paid to sampling, and this has not been done in prior research or reviews" (p. 899). For a detailed look at why researchers limit their subjects to a single sex, mostly men, see Prescott (1978). Colwill (1978) cited evidence that approximately two-thirds of the subjects in published psychological research are male. Colwill described the situation as "psychology as a masculine noun" (p. 10), and felt it is an antifemale prejudice which has a dramatic effect on theory and research.

In Block's (1976b) critical review of The Psychology of Sex Differences (Maccoby and Jacklin, 1974), one of the issues raised was the over-representation of younger age groups in the studies analyzed. Block stated that 75% of the studies involved subjects who were 12 or younger, and almost 40% used preschool children. Block argued that the age bias in the literature needs to be recognized, and the conclusions qualified because sex differences were evaluated mainly in samples of preadolescents. Block believed that inclusion of more adolescent and adult samples would reveal substantially more evidence of sex differences, as she felt the finding of sex differences is powerfully contingent upon age of subjects.

Neglect of Important Control Factors

Sherman (1978) addressed three important factors which are not controlled in most studies on male/female cognitive differences. Those factors are (1) sex-role divergence, which makes it very difficult to separate the effects of genetic sex from the effects of sex-role, (2) the years of experience in a subject, for example mathematics, and (3) course of study in investigations of spatial perception.

Hubbard and Lowe (1979) were concerned about other control factors. In discussing limitations of the models used, Hubbard and Lowe questioned whether the scientific method is applicable to the social sciences. Theoretically, in the physical sciences, all important variables are under the control of the experimenter. This is not possible in the social and behavioral sciences; "in such situations a controlled experiment is a figment of the imagination" (p. 145). Hubbard and Lowe felt that statistics offered only a partial answer to the dilemma of complex situations and comparatively simple models to use. "It is an open question whether any of the current work in the social sciences pays attention to all the important variables that influence a given behavioral trait. Thus the correspondence of any model of human behavior with the real world is problematic" (p. 146).

Maturation Rate

Addressing the investigations into male/female cognitive differences, Sherman (1978) reported "a controversial question in this field is the extent to which differences between the sexes in physical maturation are paralleled by differences in cognitive development" (p. 30). Females are ahead of males in skeletal development, and females stop growing earlier. However, females do not mature more quickly on all indices; males are ahead in sexual behavior and in attaining fertility.

There has been a long-standing debate as to whether accelerated female physical development is paralleled mentally. Sherman reviewed the often contrary finding on this subject. Although no easy resolution was found, Sherman believed it unwise to ignore the existence of this possibility. Sherman also raised the question of whether comparing the sexes of the same chronological age is a procedural bias against males. Other researchers have suggested that some differences exist as to the best timing of exposure to various educational experiences. Epstein (1974a, 1974b, 1978) and Epstein and Toepfer (1978), in studying periods of physical and mental brain growth spurts, felt the results could indicate a differential education for males and females, particularly in the middle school.

Statistical Considerations

Faulty Inferences

The sophisticated and powerful statistical techniques available today represent mixed blessings. Given the proper input, the computer's analysis can be almost instant. However, it is still left to human minds to interpret the computer's figures. This can lead to the drawing of faulty inferences, particularly in the area of male/female cognitive differences. The following are the major sources of faulty inferences derived from research.

Analysis of variance. A significant effect may be found for one sex, but not for the other; this may lead to the faulty inference of a male/female difference. However, a significant interaction effect, not just a main effect would need to be demonstrated. The conclusion of a male/female difference would require a direct statistical comparison of the two sexes. Petersen and Wittig (1979) stated that we have overused ANOVA procedures which can lead to inappropriate interpretations with male/female-difference research. They state "sex can never be a randomly assigned treatment and its role in influencing some outcome must be evaluated in relation to all hypotheses as to why sex might be important as a variable" (p. 8).

Single sex studies. A writer may refer to a study that used subjects of only one sex as if the study demonstrated a male/female difference. The study may have shown a within-sex correlation between two variables, and that finding could suggest a hypothesis about between-sex differences. However, it might later be reported as demonstrating a sex difference when in fact the opposite sex was never studied.

Within-sex patterns of findings. The following example was illustrated by both Maccoby and Jacklin (1974, p. 7) and Sherman (1978, p. 33). Preschool females were found to have more frequent verbal than physical aggression. Preschool boys were found to have more frequent physical than verbal aggression. These results were later interpreted as showing that girls were higher than boys in verbal aggression, when in fact the boys showed more of both kinds of aggression than girls.

Correlation comparisons. The comparison of an overall correlation with the correlation of one sex can lead to a faulty inference regarding male/female differences. Sherman (1978, p. 33) gave the following example. McGlone and Kertesz (1973) were investigating the correlation between Block Design and an aphasia battery for brain-injured patients of both sexes. They compared the over-all correlation of .12 with the female left-hemisphere-lesion group correlation of .63 and drew a conclusion regarding side of lesion and degree of language impairment as a predictor of female visual-spatial disability. Sherman regarded this as an incorrect test; the proper statistical test would have been to compare the correlation for males (.23) with the correlation for females (.63). Sherman felt that contrary to their report, the data did not support the conclusion drawn by McGlone and Kertesz.

Differences in correlations. A problem similar to the ANOVA problem can occur when the correlation for one sex is significantly different from zero, but the correlation for the other sex is not. It is incorrectly interpreted as showing a significant male/female difference. These spurious findings are a result of not testing the differences between the sexes, or not finding a significant difference, yet drawing an incorrect inference.

More Appropriate Statistics

Because of the inherent problems, the question arises of the use of statistics in general in research on male/female cognitive differences. The current models emphasize the establishment of differences. Thus, when we study males and females, we contrast them rather than compare them for similarities and differences. In addition, the comparisons are quantitative rather than qualitative, that being the nature of a statistical analysis. The finding "more" is interpreted as "better," and "less" is corresponded with "worse" in most cases.

Petersen and Wittig (1979) asserted that descriptive and exploratory procedures are more appropriate for learning more about males and females, rather than simply focusing on how they differ. They stated that exploratory techniques can be just as rigorous as comparative techniques; that patterns of development can be explored using various general linear model methods in place of the overused ANOVA. They felt those other techniques will allow researchers to investigate more relevant questions about male and female development.

Measures of effect size. Several authors recommended or used measures which are either free from the effects of sample size, not limited by the difficulties of the null hypothesis, or that permit an evaluation of the size of differences found between the sexes. Hyde (1981) performed a meta-analysis of Maccoby and Jacklin's 1974 analysis of studies dealing with male/female differences in cognitive abilities. Hyde chose two measures that compute the effect size, i.e., the magnitude of the male/female differences: omega squared and d. Omega squared is a measure similar to r squared, the latter being used in correlations and regression analysis. Omega squared gives the proportion of variance in the entire distribution of scores that can be accounted for by male/female differences. The remaining variance is due to within-group variation and/or errors of measurement. Hyde also chose d, a statistic defined as "the ratio of the difference between group means to the standard deviation of a group" (Hyde, p. 894).

Hyde concluded that the meta-analysis technique showed the male/female differences in the abilities under consideration were very small, amounting to no more than 1% - 5% of the population variance. Maccoby and Jacklin (1974) had contended that those differences in ability were well-established.

Sherman (1978) provided an illuminating example of the importance of measuring the extent of the difference. In a 1977 study by Fennema and Sherman, with mathematics background controlled, an analysis of variance was performed on the mathematics test scores of over 1,000 high school students. The computed F statistic of 27.47, at a probability level <.001, appeared to be a very impressive difference. However, when omega squared was used to measure the extent of the difference, Sherman reported that sex accounted for only 2% of the variance of the math achievement scores. According to Olenjik (see Note 2) the percent of variance must reach 10% - 20% in order to be considered significant, when using omega squared.

In order to double-check the Sherman (1978) finding, because the F statistic was so impressive, omega squared was recalculated using a formula supplied by Olenjik (see Note 2). This formula requires only the number of groups, the F statistic, and the total sample size. From this calculation, an omega squared of 2.57% was found, almost a duplication of Sherman's findings.

Since it is a simple matter to calculate for effect size using omega squared, it is difficult to understand why more researchers do not use and report this statistic. It seems reasonable that no study, particularly on male/female differences in cognition, should be limited to just an analysis of statistical significance. One further, simple analysis would give a much clearer picture of the study's educational and social significance as well.

Overlap. This is a simple measure which shows the percent of one group that is at or beyond the mean of the other group. An example given by Donelson and Gullahorn (1977) concerned male/female spatial ability; although the group averages were different, about 20-25% of females scored higher than the average male on tests of spatial ability (p. 9). Overlap permits comparison from study to study and across characteristics. Inferential statistics (t, F, chi-square, etc.) deal with looking at the differences between group means, i.e., with between-group variation. Group scores also vary around their own mean; this within-group variation makes it likely that the scores of the different groups will overlap. Overlap can be so great that statements about average differences are not very informative.

Conclusion

This review of the limitations of research has presented the problems involved in reading and interpreting research in male/female cognitive differences. As a result of the problems surrounding concepts, methodology, design, and statistics in this area of research, there appears to be formidable limitations to valid findings. Unfortunately, however, these limitations are all too frequently ignored. With the heavy social and educational loadings placed on the results of male/female cognitive studies, readers of those research results need to be constantly mindful of the limitations. Greater credence should be placed on those studies which approach or meet the criteria for valid research.

In addition, not only should careful attention be paid to the credibility of the research study, but also to the experimental and practical value of the testing instrument itself. An instrument of questionable worth for testing the behavior under consideration may cast serious doubt on the results from even the best of research designs. This study investigates several aspects of a number of instruments which are reported to produce male/female cognitive differences in verbal or visual/spatial skills.

CHAPTER FOUR
THEORIES CONCERNING MALE/FEMALE COGNITIVE DIFFERENCES

> The planets will move as they always have, whether we adopt a geocentric or a heliocentric view of the heaven. It is only the equations we generate to account for those motions that will be more or less complex; the motions of the planets are sublimely indifferent to our earthbound astronomy. But the behavior of men is not independent of the theories of human behavior. . . . What we believe of man affects the behavior of men, for it determines what each expects of the other.
>
> Eisenburg, 1972
> (cited in Colwill, 1978, p. 13)

As Eisenberg stated, although some things remain constant regardless of our actions to interpret them, the behavior of man is not one of them. Our beliefs, our theories about the nature of man shape what we expect from our fellow human beings. The present chapter will examine theories posited for male/female differences in one human behavior, cognition, with the purpose of shedding light on currently held beliefs concerning the subject.

The concept of cognitive differences between males and females has existed since at least the beginnings of recorded history, as evidenced by information reported in Chapter Two. Several theories have been devised and discussed which purport to explain the reasons behind the reported male/female differences in cognition. In the literature of this century, the word "hypothesis" has often been used instead of "theory" when discussing the bases of cognitive differences. This study does not intend to dwell on the semantics involved, but intends to alert the reader to the popular interchangeability of terms and phrases. Thus, when the study speaks of, for example, the "Levy-Sperry hypothesis," the common-usage phrase is being reported, when in fact the phrase "Levy-Sperry theory" would be more appropriate.

Theories explaining the reported male/female differences in cognition are not limited to publication in professional journals. Newsweek (Gelman, 1981) and Playboy (Durden-Smith & DeSimone, 1982) ran articles on the differences between the sexes which included theoretical explanations of those reported differences, complete with dialogue on the subject from leading authorities in the field of male/female differences. Granted, it is the reporter's duty to report. However, the theories espoused or the bases on which they rest are never questioned. In the popular articles, the reported theories are accepted as The Truth, and are used to explain the researcher's findings. Fortunately, that is not the situation in all professional journals; it is there that colleagues frequently challenge theories espoused by their peers.

This chapter will describe several theories concerning male/female cognitive differences. When the information is available, the bases of each theory will be reported, along with the major proponents of that theory. Additionally, opposing points of view will be reported, so that the theory may be examined in light of contrary thinking and/or evidence. The theories, called "hypotheses" by their authors and reporters, to be examined in this chapter will be (a) the variability theory, (b) the X-linked recessive gene theory, (c) the Levy/Sperry theory, (d) the Buffery/Gray theory, and (e) the Bent Twig theory. The variability theory is concerned with cognitive differences in general, and the remainding four theories are more concerned with specific differences, mainly verbal and visual-spatial.

Commonality of Theories

Throughout the variety of theories encountered in the literature which are concerned with explanations of male/female cognitive differences there runs a common thread which is, in and of itself, the basic theoretical underpinning. That common thread is the belief in a biological basis for most, if not all, male/female differences. The biological basis is intertwined with the evolutionary theory of adaptive specialization.

The evolutionary theory holds that throughout history the two sexes have become specialized in their general characteristics, a specialization which is necessary for survival of the species. The female specialized in bearing and nurturing the young, and the male in hunting food and providing protection. This basic sexual dimorphism, manipulated by evolutionary progress, is believed to have resulted in the variety of human sex differences reported today. Gray and Buffery (1971) believed the differences in emotional and cognitive behavior were necessary consequences of the division of labor between the sexes in reproductive behavior, "that is to say, they are specified in the gene pool of our species" (p. 107).

This theme of evolutionary, biological foundations of male/female differences surfaces again and again in the discussions of the various theories. At times its presence is subtle, at other times noticeable, but the biological thread is ever present.

Variability

Commonly referred to as the variability hypothesis, this theory is one of the oldest of theories attempting to explain male/female cognitive differences, yet one that is still well accepted in modern times. Believed to have its roots in Darwinism and in the late 19th century theory of Geddes and Thompson (see Sherman, 1979 and Shields, 1975) its basic tenet is that males are more variable than females and this accounts for males' superior intellect. The following account will investigate several aspects of reported greater male variability.

Variability in Metabolism

According to Shields (1975), Geddes and Thompson believed in a dichotomous male/female difference in metabolism. Males were seen as primarily anabolic, a term which describes the process in a plant or animal by which food is changed into living tissue. Females were viewed as catabolic, a term describing the process in a plant or animal by which living tissue is changed into waste products of a simpler chemical composition. The former is considered a constructive metabolism, while the latter is destructive metabolism. "From this difference in metabolism, all other sex differences in physical, intellectual, and emotional makeup were derived" (Shields, 1975, p. 746). The female was seen as less variable, more conservative, truer to the species; thus her nature ensured the continuity of the species. The male was viewed as more creative, more agile, more variable.

Variability in Male Animals

Sherman (1978) believed the notion of greater male variability is the result of a tenuous derivation from the evolutionary theory. Theoretically, if evolution proceeds in part by sexual selection, and if the emphasis is on the female selecting the male for mating purposes, then the male with the most attractive or successful characteristics would be chosen, thus ensuring continuation of those characteristics. According to Sherman, the idea was bolstered by the common observation that male animals are often more spectacular in appearance than female animals. The purpose of this more variable, more spectacular appearance on the part of the male animal was to attract the female. Thus greater male variability in some species became a means of ensuring perpetuation of the species. "So the theory that explained the peacock's tail was haphazardly transferred to the human conditions and physical appearance applied to the mental condition" (Sherman, 1978, P. 10).

Variability in Anatomical Traits

The comparative variability of the sexes was first discussed in the early 1800's and was related to anatomical traits. Meckel, an anatomist, drew a conclusion based on pathology that the human female was more variable than the human male, that variation was a sign of inferiority, and that the male was the superior animal. However, scientific logic did a flip/flop when, at a later date, the anatomists and naturalists decided that the male was more variable than the female, and that variability "was an advantage, a characteristic affording the greatest hope for progress, and finally as the probable explanation of the fact that all the world's greatest deeds of intellect have been deeds of men" (Hollingworth, 1914, p. 510).

Variability in Mental Function

By the late 19th century, the variability hypothesis was commonly accepted as an explanation of why there supposedly were more male than female geniuses. Geddes and Thompson held "that men should have greater cerebral variability and therefore more originality, while women have greater stability and therefore more 'common sense,' are facts both consistent with the general theory of sex and verifiable in common experience" (Sherman, 1978, p. 100). Thorndike, the founder of the connectionism theory of behavior, believed firmly in the existence of great differences between the sexes in intellectual achievement as well as eminence, and felt the difference was due to the inherently greater variability of males.

> The trivial differences between the central tendency of men and that of women which is the common finding of psychological tests and school experience may seem at variance with the patent fact that in the great achievements of the world in science, art, invention and management, women have been far excelled by men. One who accepts the equality of typical (i.e., modal) representatives of the two sexes, must assume the burden of explaining this great difference in the high ranges of achievement. . . . . The probably true explanation is to be sought in the greater variablity within the male sex. . . . In particular, if men differ in intelligence and energy by wider extremes than do women, eminence in and leadership of the world's affairs of whatever sort will inevitably belong oftener to men. They will oftener deserve it. (Thorndike, 1910, p. 35)

The variability theory has been supported by reports that not only are there more male geniuses, but there are also more male mental defectives. Ellis (1894) found great social significance in the theory of greater male variation; he believed it resulted in men of genius. Of the female's reported tendency towards the average, Ellis felt it limited her "to the sphere of concrete life" (p. 436). Hollingworth (1914), a former student and then colleague of Thorndike's at Columbia's Teachers College, critically discussed the theory of greater male variability. Hollingworth related that even among authors, there was a failure to define the term itself.

Variability and range of distribution. The theoretical definition of greater variability always implies a greater range, if the trait so distributed conforms to the Gaussian curve of probability which is a symmetrical, bell-shaped curve. The assumption of normality is extremely important to the validity of the variability hypothesis, for only in a normal distribution would a difference in variability indicate a difference in range. Hollingworth stated that greater variability was found to consist of any of four typical distribution conditions, and presented a hypothetical case to prove the point (see Hollingworth, 1914, p. 514).

Hollingworth felt that even if the greater variability of males were to be proven, in order for social significance to be attached to it, not only must the coefficient of variation be stated but also the form the distribution takes. According to Hollingworth, only one of the four possible distributions could be used as evidence that all the world's greatest deeds of intellect have been the deeds of men.

Clinical evidence regarding variability. Hollingworth (1913) investigated one line of evidence supporting the variability theory, that of greater numbers of mentally defective males than females. Hollingworth ran a statistical investigation of the individuals who passed through the Clearing House for Mental Defectives in New York City. In 1,000 consecutive cases diagnosed, the results were tabulated by sex, by frequency and by age. There were 136 more males than females in the study. Both sexes showed age distributions skewed towards the higher ages. In other words, the majority of clients appeared while in childhood, adolescence, or early adulthood.

"At the age of 1-2 years the frequency of mental deficiency for the sexes is equal. From 2 to 16 years the frequency for males is very much greater than for females. At the age of 16 the curve for the females crosses that for the males, and from that point on the frequency for females is much greater than for males" (Hollingworth, 1913, p. 755). Additionally females showed an age range from 1-54 years while the male range was from 1-47 years. Hollingworth's evidence contradicts Thorndike's (1910) statement of evidence supporting greater male variability and thus greater male intellectual prowess. It was Thorndike's contention that males exhibit a greater range in the distribution than females and this greater range is evidence of their greater variability. It would appear from at least the Hollingworth study, that greater male range is not true, and thus raises the question of the validity of greater male variability.

Hollingworth (1913) presented tables showing that for all mental ages the average actual age of examination at the Clearing House is older for girls than for boys. The difference became very marked after the mental age of 6-7 years. Hollingworth believed this showed that a female with a mental age of 6 years survives in the social milieu about as well as does a male with a mental age of 10 or 11 years. Females survive in the social milieu until beyond the age of 16 years twice as frequently as males, and until beyond the age of 30 years three times as frequently as males. Hollingworth also stated the tables indicated that any boy of a given degree of defectiveness is much more certain to be brought to the Clearing House at a given average age than is any girl of the same degree of defectiveness. Hollingworth (1913) concluded that those facts are a reflection on our social organization.

> Women are not a competitive class. Their work is housework, performed in isolation and not in competition with others for a wage. Moreover, in our social organization, sex as such may easily become a commercial asset to women, and open to them ways wherein they can survive without much regard to mental deficiency. Men, on the other hand, form a highly competitive class, working together in competition for a wage. The boy that cannot compete mentally becomes at an early age an object of concern to relatives, is brought to the clinic and is directed toward an institution. The girl who cannot compete mentally is not so often recognized as definitely defective, since it is not unnatural for her to drop into the isolation of the home where she can take care of small children, peel potatoes, scrub, etc. If physically passable, as is often the case, she may marry, thus fastening herself to economic support; or she may become a prostitute, to which economic pursuit feeble mentality is no barrier. Thus they survive outside institutions. (p. 756)

Thus what had been interpreted as evidence of greater male variability might in truth be a reflection of cultural processes. Hollingworth (1913) concluded that if social pressures had been applied equally to males and females there would have been equal representation of the sexes at the Clearing House. Concerning the rarity of eminence among women Hollingworth (1914) held that "housekeeping and the rearing of children, though much commended to women as proper fields for the exploitation of their talents, are, unfortunately for their fame, not the fields in which eminence can be attained" (p. 526) and "men of science who discuss at all the matter of woman's failure should thus seek the cause of the failure in the most obvious facts" (p. 528).

Variability and Eminence

It should be borne in mind that the classifications of eminence were devised by males (see Thorndike, 1910 and Cattell, 1903). They thus have a value attached that might not be present if the classification scheme had been devised by females.

The notion of male eminence persists today. Blakeslee (1980) asked why there were no women Beethovens, why there are as yet no towering female geniuses. Blakeslee stated

> Certainly lack of opportunity or aspiration can account for much of this gap, but the towering genius is such a standout that poverty and persecution have seldom stood in his way. Many women show early promise, achieve recognition and fame in a pattern similar to the towering genius, but that final rise to the sublime level just never happens. (p. 107)

Blakeslee (1980), rather than attribute females' lack of eminence to variability, has molded the notion into the current thinking of this decade. He attributes the reported lack to the females' functional brain organization, where the two hemispheres of the female brain work as a pair of generalists, and the male brain is more like a pair of specialists (see p. 107). The idea of attributing two separate modes of thinking to males will be elaborated upon in a later chapter.

Variability and Evolution

Not all scientists studying male/female differences have embraced the notion of greater male variability. The most notable exception is Karl Pearson, who developed a technique known to all students of statistics, the Pearson Product-Moment Correlation Coefficient. Soon after Ellis discussed the variability theory in his book Man and Woman (1894), Pearson (1897) charged that the theory was "pseudo-scientific superstition" and the idea of greater male variability was contrary to the fact and theory of evolution and natural selection.

According to Pearson (1897), evolutionary theory held that "the more intense the struggle the less is the variability, the more nearly are individuals forced to approach the type fittest to their surroundings, if they are to survive" (p. 258). Pearson argued that Ellis should not have considered secondary sex characteristics, and that Ellis should not have contrasted the sexes on the basis of abnormalities. Pearson limited his measures to normal variations of non-secondary sex characteristics, and based his contrasts on dispersion of measures around the mean, not the extremes of the distribution. With the redefinition and reanalysis, Pearson found a slight tendency toward a greater female variability.

Variability and Abnormality

Sherman (1978) reported on the second issue raised by Pearson, the investigation of abnormalities

> Long ago Karl Pearson pointed out that if what was being studied was the extent of normal variation in the two sexes, then only normal persons should be included in the sample. If one is seriously evaluating the *variation* idea within the evolutionary context, use of *only* normal subjects is appropriate. However, much of the evidence cited in discussing this idea . . . dwells on the percentage of mental defectives and geniuses among the two sexes. (p. 71)

Sherman (1978) contended that "variation" has been translated into "variability" in modern discussions. Thus if variability is to be evaluated in the population, then nearly everyone in a given population must be studied in order to get an unbiased sample. "Unless nearly *all* the population is studied biasing factors are free to operate" (p. 71).

Additionally, Sherman (1978) believed that it was a totally inadequate evaluation of the variability question if one simply compared male and female standard deviations on various tests, without regard to questions of selection or type of test used. Recognition of relevant socio-cultural factors is also important, according to Sherman, as they are clearly involved in the development and social recognition of genius status. "The factors that account for the excess of male mental defectives are probably different from those that account for the excess of male geniuses. For example, biology may explain the former while social factors may explain the latter" (p. 73).

X-linkage

In the past two decades, evidence has been presented which suggests that a recessive gene on the X chromosome enhances performance on tasks requiring spatial visualization, and this recessive gene enhances males' superior spatial skills. In order to understand the theory of the inheritance of cognitive skills via an X-linked recessive gene, it is necessary to delve into genetics.

Every human cell contains 46 chromosomes, arranged in 23 pairs. One chromosome of each pair is contributed by the mother of the individual and one by the father. Twenty-two of the chromosome pairs carry genes that determine hereditary characteristics of the person. The twenty-third pair is called the sex chromosomes and differs for men and women. If the individual is a female, the sex chromosomes are represented as XX; if male, the pair is designated as XY. Only males carry a Y chromosome, which is very small and carries little genetic material. Genes carried on the sex chromosomes are called sex-linked genes, and all but one are carried on the X chromosome. Sherman (1978) preferred the term "X-linked" to "sex-linked" because of its greater precision, and "X-linked" will be the term used in this study.

Basically, the X-linked theory holds that a high potential for a characteristic is carried on the X chromosome. If the X-linked trait is recessive, more males than females will be affected, whereas if the X-linked trait is dominant, more females than males would be affected. If the theory is true, then males would have a higher potential for spatial visualization, as they would need to inherit only one X chromosome with the recessive gene on it in order to produce that characteristic, while females would need to inherit two such X's.

Maccoby and Jacklin (1974) have reported that gender differences in spatial ability are "well-documented" and report several studies which suggest a genetic X-linkage for spatial ability. The leading proponent of the X-linkage theory, Stafford (1961), believes that at least one important genetic determiner for spatial ability is recessive and is carried on the X chromosome. Stafford reported patterns of parent-offspring correlations which were suggestive of the reasons for greater male spatial ability. As Sherman (1978) pointed out, if this theory is true it would go a long way toward explaining the scarcity of women in math and science.

Sherman (1978) proposed that there are three ways to test the X-linked theory: (a) comparing identical male and female twins, (b) observing the variations in intra-familial correlations and (c) examining score distributions for their conformity to theoretically predicted distributions (p. 76). Sherman provided a lengthy discussion of all three tests of the theory (p. 75-87) and concluded the theory has been disconfirmed.

> The widespread acceptance which the hypotheses found was premature . . . and the subsequent accumulation of negative findings have thoroughly borne out that assessment. The evidence cited as favoring the hypothesis that spatial visualization is a sex-limited characteristic is selective, insubstantial, and does not support the hypothesis. . . . The poor quality of much of the evidence adduced to support these theories should be evident to anyone who has closely examined the evidence presented. The need for greater rigor and higher scientific standards is self-evident. (pp. 86-87)

In support of Sherman's (1978) conclusion, Bouchard and McGee (1977) have also refuted the X-linked theory. Bouchard and McGee obtained spatial visualization scores on two hundred families. Although they found large sex differences favoring males in both the parents and the offspring, the familial correlations did not order themselves as predicted by the X-linked recessive gene theory. They believed instead that the results were compatible with a sex limitation and/or socialization theory of ability acquisition. McGee (1979) reviewed the research on the X-linked theory of inheritance of genes controlling sex differences in major intellectual traits and found that the evidence does not support the theory. "Estimates of its [heritability's] value can be made larger or smaller merely by altering the amount of environmental variation present in the population under study. This is why estimates of heritability such as those based on intrafamily correlations tell one nothing about how similar two person's IQ scores might have been had they been reared under more diverse or less diverse environmental conditions" (p. 72).

Since the X-linked theory has fallen into general disrepute, based on reports of researchers from 1975 on, the theory will not be discussed further. The interested reader is referred to the above mentioned citations for further elaboration on the theory and the evidence refuting it.

Brain Lateralization Theories

For a normal, right-handed person, the two hemispheres of the brain are thought to specialize in somewhat different manners, with the left hemisphere specializing in verbal, analytical tasks and the right hemisphere specializing in spatial, gestalt tasks (see Dimond and Beaumont, 1974). The term "brain lateralization" usually refers to the degree to which the left hemisphere has specialized, or established dominance, for verbal, analytical functions, particularly speech. The following two theories, commonly called "hypotheses," have been among the most widely discussed and believed theories about male/female differences in brain lateralization, a term also known as "brain asymmetry" and "brain specialization."

Both theories are based on alleged male/female differences on spatial and verbal tasks, and they represent two entirely different approaches to, and reasonings from, basically the same set of facts. They are in agreement on one conclusion, that females are inferior to males on spatial tasks. The reasons behind the alleged inferiority define the contradictory conclusions that have been reached by these researchers. The contradictory conclusions appear to turn on the assumed degree of lateralization in the female brain.

The Levy/Sperry Theory

Frequently referred to in the literature as the "Levy Hypothesis," this theory was first presented by Levy in 1969. Levy had been a protogee of Roger Sperry at the California Institute of Technology, where Sperry researched differences in hemispheric function in epileptic patients who had undergone separation of the fibers connecting the two hemispheres of the brain. Subsequently, Sperry was awarded the Nobel Prize in 1981 for his work on the brain and its functions. While at CalTech, Levy (1969) hypothesized that during the human evolutionary process, gestalt perception was lateralized to the right hemisphere as a consequence of an antagonism between the functions of language and perception. Levy (1974) stated

> Given several millions of years to operate and a fortunate mutation which induces cerebral asymmetry of function, it is clear that through the processes of natural selection, evolution will drastically increase the frequency of that phenotype which, as it were, possesses the best of both worlds in terms of perceptual and conceptual behavior. Those anthropoids with functionally symmetric brains who have also evolved language will, in general, be significantly less adapted (or adaptable) than their asymmetric cousins, being deficient in right or hemisphere processes [sic], the level of deficiency being determined by the degree of symmetry. (p. 167-8)

Reasoning that persons with language centers in both hemispheres would perform relatively poorly in tests of perceptual function because of the competitive antagonisms between the two hemispheres, Levy (1969) set out to test that hypothesis. The subjects investigated were all male graduate science students at CalTech, ten of whom were left handed and fifteen of whom were right handed. Operating under the assumption that sinistrals (left-handers) are known to have less well differentiated hemispheres in respect to linguistic capacity than dextrals (right-handers), Levy compared the subjects' verbal and performance scales on the WAIS (Wechsler Adult Intelligence Scale).

An additional assumption by Levy was that the verbal scale of the WAIS reflects major (left) hemisphere abilities and the performance scale reveals minor (right) hemisphere abilities. Levy admitted that the graduate science students were a select population, but thought them representative of the left- and right-handers in the larger population. It should be mentioned here that Levy's sample was a very high IQ group. The lowest score registered on the WAIS for this sample was 117 (performance) and the highest score was 142 (verbal). Levy found a verbal/performance discrepancy of 8 points for right-handed males (138/130), but an even larger verbal/performance discrepancy score of 25 points for left-handed males (142-117). In addition, left-handers scored slightly higher on the verbal but much lower on the performance scale than right-handers. From these data, Levy concluded that bilateral language capacity (as evidenced by sinistrals) seemed to interfere with abilities associated with the minor (right) hemisphere, i.e. spatial skills.

From these data and from evidence gathered from split-brain patients, a generalization was made to explain the alleged inferiority of females on spatial skills. Star (1979a) has spoken to this subject

> Levy and Sperry begin their reasoning by noting that females perform poorly on certain tests for spatial abilities, and that left-handed men perform poorly on the same tests. Left handers, they state, perform poorly on these tests because of "cross-talk" from their left hemispheres while performing the tasks: they are said to be less lateralized. The authors argue that the superiority of right-handed males in such spatial tasks is due to *greater* lateralization of the two hemispheres; Levy states "it might be that female brains are similar to those of left handers in having less hemispheric specialization than male right-hander's brains." (p. 66)

A further analogy between females and left-handers was drawn by Levy and Sperry. They believed that in left-handers both sides of the brain mediate language, whereas in right-handers it is a left brain function. The language component in the right hemisphere of left-handers is what interferes with the right hemisphere's performance on spatial tasks. "From this Levy and Sperry generalize to females who, they assume, also have bilateral representation for language, and they conclude that this is why females as a group perform more poorly on spatial tasks" (Star, 1979a, p. 66). Marshall (1973) has presented evidence that in fact left-handers do not usually have bilateral representation.

As Star (1979b) pointed out, a number of researchers have already begun to accept the Levy/Sperry theory as fact, and have used it to interpret further findings although there are many problems associated with it. Star concludes

> Levy and Sperry do not address training and socialization as possible factors in performance of spatial tasks. They do not verify their assumption that the tests measure the degree of hemispheric specialization. And they do not address the critical fact that females consistently perform better than males on tests of verbal ability, a fact which would seem to contradict their assumption that females have bilateral language representation (which, by their reasoning, should make their verbal abilities poorer). Rather, they seem more interested in explaining male superiority on spatial tasks, whatever contortions of logic this might demand. (p. 121)

Critiques of the theory. There are a number of conceptual and methodological difficulties with the Levy/Sperry theory. As Marshall (1973) pointed out, the theory depends critically upon the truth of its initial assumption, that bilateral mediation of verbal skills will be found in a substantial proportion of the normal left-handed population. Marshall reported that "results from sodium amytal testing and unilateral ECT studies lead one to suppose that no more that 20 percent of left-handers have an appreciable degree of such bilaterality" although it is argued that "a substantial proportion of familial left-handers may have bilateral language representation" (p. 464). McGlone and Davidson (1973) tested males and females and found that only those left-handers who exhibited right hemisphere dominance (as assessed by a dichotic listening procedure) were inferior to right-handers on a spatial relations test. Furthermore, McGlone and Davidson could not confirm the interhemispheric competition hypothesis as posited by Levy and Sperry. In those subjects with both verbal and non-verbal cognitive functions mediated by the same hemisphere, there was no evidence of inferior performance.

Sherman (1978) presented an in-depth critique of the Levy theory, which states basically that "because women have more bilateral representation of verbal function and because hemispheric specialization results in maximal cerebral organization, females perform more poorly on spatial tasks" (p. 117-18). Sherman evaluated the theory on the bases of (a) evidence of verbal bilaterality in females and (b) evidence supporting the maximal cerebral organization theory. Summarizing the evidence for the first proposition, Sherman found that the data do not support the conclusion that females have more bilateral verbal representation than males. Sherman stated that some of the data (a) are subject to other interpretations, (b) have been inappropriately cited, (c) have not been firmly established, and (d) are frankly contradictory.

> The contention that females are more verbally bilateral because they recover faster from aphasia, even if true, is subject to other interpretations. The temporal lobectomy data do not clearly support the contention. Studies of

> unilateral electroshock provide no support while evidence from tachistoscopic and dichotic listening studies are equivocal. Evidence from anatomical studies requires replication, more adequate statistical tests, and the ruling out of alternative explanations. Data from studies of brain-injured persons are not clear cut and data from commissurotomy patients were inappropriately cited. In summary, there is no clear evidence that females are verbally more bilateral than males. (Sherman, 1978, p. 123-4)

The second proposition of the Levy theory, that cerebral hemispheric specialization maximized intellectual functioning, was based by Levy (1969) on the finding that left-handed males showed lower spatial than verbal performance, and a lower spatial performance than right-handed males on the WAIS. Sherman (1979) used a larger, less select sample of high school students, and found no replication of the Levy result regarding depression of spatial performance in left handed males. It should be noted, however, that Sherman's subjects were all math students, and the dependent measures used were not the same as those used by Levy. Sherman concluded that her results did not support Levy's findings nor the hypothesis of maximal cerebral organization, and were "totally inconsistent with the Levy explanation for verbal-spatial patterning in females" (Sherman, 1979, p. 388).

Sherman (1979) felt her own findings strongly suggest the factors that account for cognitive patterning associated with handedness are not the same factors that account for cognitive patterning associated with the two sexes. "Levy's general hypothesis will need to be modified, and her hypothesis that sex-related differences can be attributed to less lateralization of female verbal function is not supported" (Sherman, 1979, p. 389). Although Sherman (1978) rejected the theory that females are cognitively organized like left-handed males, judgment was reserved on the hypothesis that females are more verbally bilateral than males because of ambiguities in the findings. "There does appear to be evidence that females use the left hemisphere for spatial function more than do males. This would not necessarily make them more bilateral in spatial function, but could constitute a difference in problem approach" (Sherman, 1978, p. 134).

Maccoby and Jacklin (1974) noted that some puzzling questions arise from the work on brain lateralization in the two sexes.

> One is that the 'packages' of skills localized in each hemisphere do not correspond in detail to the known sex differences in abilities. Levy-Agresti, for example, has described the left hemisphere as being verbal, sequentially detailed, analytic, and computer-like. Although girls are superior in a variety of tasks, the rest of the description does not fit them better than boys. A theory that purports to account for female superiority on verbal tasks and inferiority on spatial tasks, in terms of stronger or earlier lateralization of the left hemisphere, would have to expect that the other functions controlled by this hemisphere would also be superior in girls. (p. 126-7)

The Buffery/Gray Theory

Whereas Levy/Sperry believed that male superiority in spatial tasks stemmed from greater specialization of the two cerebral hemispheres among males than females, Buffery and Gray (1972) contend the male superiority results from a lesser degree of specialization. They have hypothesized that dominance of the left hemisphere for verbal function is attained earlier in females than males, which leads to less bilateral representation of the spatial function in females. Buffery and Gray believe that bilateral spatial representation is beneficial to superior spatial functioning. Thus a lack of spatial bilaterality would account for poorer spatial performance.

As Sherman (1978) pointed out, the Buffery/Gray theory and the Levy/Sperry theory are in fundamental contradiction, but are not direct opposites. Buffery/Gray contend that less lateralization results in development of better spatial skills; Levy/Sperry contend that more lateralization results in development of better spatial skills. Both agree, however that males have superior spatial skills; the disagreement rests on the theoretical reasons behind the alleged male superiority.

Marshall (1973) held that although Buffery and Gray provided an excellent summary of the data consistent with their theory, the available evidence does not "unequivocally support their position: and "the evidence for biologically-determined sex-differences in visuo-spatial ability (in normal human subjects) is far from conclusive" (p. 465).

Star (1979a) found three serious problems with the Buffery/Gray theory. First, attribution of a global or gestalt perception to the spatial tasks used in the studies, namely the Rod and Frame Test and tests dealing with figure/ground discriminations, "requires a bit of imagination" (p. 67). These tests will be further discussed in Chapter Six of this study. Second, Buffery and Gray (1972, p. 127) casually mentioned that the only tasks that show males are spatially superior are tests of manipulation of the environment or some part of it. Star stated "the equation of this with spatial ability, not to mention its high valuing, reflects the respect accorded the skill of manipulation in this society" (1979a, p. 68). Buffery and Gray (1972) did allow that females were better than males on a number of other tests of visual matching and visual search "which are predictive of good performance on clerical tasks" (p. 127). The third theoretical problem reported by Star (1979a) was that

> Buffery and Gray, like Levy and Sperry, never verify the brain activity they associate with particular tasks. They *postulate* that men are less lateralized than women: they *postulate* that verbal skills require greater lateralization, and visuo-spatial skills less lateralization. But they never measure with brain wave recordings (EEGs) or other tests the actual brain activity of males or females during the performance of any of these tasks. (p. 68)

Fairweather (1976) contended that the documentation supporting the propositions outlined in Buffery and Gray's (1972) developmental and neuro-psychological model were inadequate. Sherman (1978) alleged that the assumptions of the Buffery/Gray theory did not hold up under scrutiny, and the "theory is clearly and consensually rejected" (p. 116). Little evidence can be found in the professional literature that gives support at present to the Buffery/Gray theory although Maccoby and Jacklin (1974) refer their readers to Buffery and Gray (1972) for "detailed documentation. . . of the work on sex differences in cerebral dominance" (Maccoby & Jacklin, 1974, p. 126).

Marshall (1973) has addressed the feasibility of continued investigations into the validity of the two major brain lateralization theories.

> The form of brain organization that, according to Levy and Sperry, results in the right-handers *superiority* in visuo-spatial tasks is the same form of organization that Buffery and Gray claim leads to the *inferiority* of women. One can, of course, attempt to reconcile the two accounts by proposing, for example, that all women and left-handed men have bilateral language representation but unilateral (right-hemisphere) visuo-spatial representation, whereas right-handed men have some degree of bilateral visuo-spatial representation but unilateral (left-hemisphere) language representation. Testing more elaborate compromises will not, however, be easy, and one may in any case wonder whether such Venn-diagram approaches to brain organization may not be profoundly misleading. (p. 466)

The Bent Twig Theory

The least well-known of the theories espoused to explain male/female cognitive differences, the Bent Twig theory was first described by Sherman (1967) in a review of problems of male/female differences in space perception and intellectual functioning. According to Sherman (1978) the Bent Twig theory relies on the law of primacy: that which is established first is preferred and more firmly set. Thus, since females are apparently verbally accelerated compared to males, females come to rely on verbal approaches to problem solving more than do males. In other words, according to Sherman (1978) females develop a preference for a verbal problem-solving approach.

Since it appears that females as a group are more verbally precocious than males (see Maccoby, 1966; Maccoby & Jacklin, 1974) Sherman (1967) theorized that this precocity "bends the twig," so to speak, for females to rely on a verbal, socially mediated approach to problems. Using a verbal approach, females may not exercise and develop spatial skills; this trend would be supported by the cultural sex-typing of activities. Males on the other hand, who are not verbally precocious as a group, may use their superior musculature to get what they want. "Less able to control and be controlled by verbal means, the stage could already be set for sex differentials in active exploration and problem solution by action rather than words for males" (p. 296-7). Sherman theorizes that this action-oriented, non-verbal approach used by males may become more easily fixed, with the result that verbal behavior fails to develop adequately.

Sherman (1978) resurveyed the literature concerning female verbal precocity and concluded the evidence supported the Bent Twig hypothesis. According to Sherman, females probably have a headstart in verbal skills "and certainly girls and women more than hold their own in all aspects of the verbal area including verbal reasoning and vocabulary, as well as verbal fluency" (p. 43). "We will tentatively conclude that more girls than boys effectively use language at an early point. Note that the emphasis is on effective use of language, a concept which can include several measures" (p.113).

In a discussion of Sherman's theory, Maccoby and Jacklin (1974) reported that the developmental pattern was quite different than Sherman reported. Maccoby and Jacklin found no sex differences in verbal vs. spatial thought in the years boys lagged behind girls in lateralization, but sex differences in modes of thought did appear at an age when boys had caught up and become as lateralized as they ever would be.

Maccoby and Jacklin (1974) expressed several reservations with the Bent Twig theory. They believed that:

1. far-reaching, qualitative changes in intellectual processes occur with development
2. large transformations in modes of thought do occur in middle childhood, after lateralization is virtually complete
3. the chances are slim that early habitual reliance on one kind of data will survive those transformations (p. 127).

Maccoby and Jacklin (1974) suggested that an appropriate test of the Bent Twig theory would be an examination within sex of the relationship between the rate of early language development and later spatial skills. Sherman (1978) felt Maccoby and Jacklin fell into the error of making faulty inferences about between sex differences from within sex data. Sherman stated

> In addition to misrepresenting the hypothesis, Maccoby and Jacklin suggested that the way to test the 'bent twig' hypothesis is to see whether boys who speak late have better spatial skills than boys who speak early. On the surface this appears to follow logically but in fact, it does not. The converse of a true statement cannot be assumed to be true. An assertion that verbal precocity in girls more than boys leads to establishing a perference for the verbal approach in females, does not logically permit the inferences they made. Shifts were made from girls to boys, from between sex differences to within sex differences, from the verbal area to the spatial area, and from preference for a verbal approach to skill in spatial performance. (p. 21)

Archer (1976), in a discussion of the biological explanations for psychological male/female differences, gave support to the interactionist model proposed by the Bent Twig theory. Sherman (1978) provided a suggestion for research on the subject. If a verbal approach preference and lower spatial skill can be observed in girls and boys who talked early, in comparison to girls and boys who talked later, and relevant factors such as possible brain damage and socioeconomic background were controlled, the finding could shed some light on the validity of the Bent Twig theory.

Conclusion

The preceding discussion has highlighted the major theories found in the literature which purport to explain the alleged male/female differences in cognition. No attempt has been made to examine each or any theory in detail, as that is beyond the purposes of this study. The literature regarding these theories, and the evidence supporting or disclaiming them, is vast, confusing and often contradictory. Support or disproof of any particular theory appears to depend, to at least some degree, upon the philosphical leaning of the researcher or investigator reporting the information.

An attempt has been made in the present chapter to familiarize the reader with the salient points of each theory while avoiding, as much as possible, the taking of a judgmental stance. Presentation of the theories makes, at least on the surface, interesting reading. On a deeper level, knowledge of forces impacting on an ability such as cognition can give pause for reflection. If any of the theoretical bases prove out to be true, then future decisions regarding cognitive growth will turn on the immutability or malleability of the causes delineated in that theoretical base. Additionally, by being made aware of theoretical underpinnings, assessment of research findings on male/female differences in cognition may be viewed in a new or different light.

CHAPTER FIVE
POSSIBLE INFLUENCING FACTORS ON MALE/FEMALE COGNITIVE DIFFERENCES

The previous chapter, Chapter Four, investigated the theories posited to explain male/female differences in cognition, particularly in the area of verbal and visual/spatial skills. The present chapter will examine influencing factors or variables reported in the literature which are believed to affect to some degree the development of cognition in general and verbal and visual/spatial skills in particular.

The categorical division of theories and influencing factors into two separate chapters is arbitrary at best. In the first place, many sources describe both the theories and the influencing factors as though they are one and the same. In addition, it is difficult to sever the conceptual connection between theory and influencing factors. In some instances the influencing factors have become the foundation of theories about male/female cognitive differences. In other instances, it appears as though influencing factors have been enumerated and described in order to support a preconceived theory. In reality, theories about cognitive development and beliefs about factors which influence cognitive development are so interwoven and interacting it is difficult to rationalize a plausible division. However, for the purposes of this study, the division of these concepts into two discrete categories aids in the gathering and reporting of data.

The reader must be aware that in the following discussion of factors which influence cognitive development it will be impossible to completely segregate these factors from the theories which were covered in Chapter Four. Thus, reference will be made in this chapter to theories previously discussed, and reiteration of concepts from the prior chapter will of necessity be incorporated into the present discussion.

The influencing factors discussed in this chapter will be the following: (a) hormonal, (b) developmental/maturational, (c) physiological/morphological, and (d) hemispheric specialization. It will soon become apparent to the reader that it is impossible to completely separate these factors from each other. They also work interactively and can be viewed as melding into a composite, multifaceted, variable. In other words, each factor could be seen as drawing upon some factors and then leading into other factors. Thus, discussion of each factor listed above may touch upon others mentioned. An understanding of the complexity of factors which can influence male/female differences in cognition is as involved as the complexity of cognition itself.

Hormonal Factors

In an integrative review of the literature concerning the effects of fetal hormones on the brain and on human sex differences, Reinisch (1974) stated "many investigators of sex differences have suggested that underlying physiological-biological factors probably account, at least in part, for some of the sexually dimorphic behaviors identified in humans. The evidence suggests that it is the presence or absence of androgen during the period critical for the organization and differentiation of the human brain that is the operative agent" (p. 51). Petersen (1976) has suggested that the effects of prenatal hormones explain male/female cognitive differences. This explanation is based on the knowledge that humans, like lower species, go through a critical period in prenatal development when the sex hormones "prime" or organize the brain for later sex-related behavior.

Estrogen and Androgen

It is during the species-specific critical period, which is very early in the developmental pattern, that the sex hormones can differentially organize the brain for male or female behaviors. According to Levine (1966) and Konner (1982) the developing embryo will assume the female form unless androgen is present during this critical period. This concept, based mainly on studies with lower order mammals (Levine, 1966), has been the fodder for a gamut of arguments. These arguments have ranged from the belief that the female embryo is perfect unto itself since it needs no additions, to the notion that only the male form is the completed form as it has had something extra added.

Although the presence of this fetal androgenic substance during the critical period of brain development has been shown to differentially affect male/female behaviors in rodents and the lower primates (Reinisch, 1974), its influence on the neural and behavioral organization of humans is still in question. The question arises, in part, because most findings about hormonal influences on the brain have come from either animal studies, or what is known as human clinical syndromes. Patients with clinical syndromes have some type of hormonal or endocrine system abnormality, either of endogenous or exogenous origin. Thus there is the problem of the generalizability of results from abnormal to normal populations.

The two main sex hormones in the human body are estrogen and androgen. Although normal males and females possess both hormones, they do not have both hormones in equal amounts. Normal males have more androgen than estrogen, and for normal females the situation is reversed. According to Sherman (1978) the sex hormones are all closely related chemically and can change from one to the other in the body. Thus "androgens can be converted to estrogens in the brain so what seems to be an androgen effect may, at another level, be an estrogen effect" (Sherman, 1978, p. 105). In support of Sherman's contention, Bleier (1979) reported that brain cells and many other cells of the body can convert androgens to estrogens; thus it may be the estrogens which are evoking the effects found. Sherman felt this phenomenon accounted for many paradoxical effects of sex hormones and for some of the confusion among those who review and report the research findings.

As an example of the paradoxical effects of sex hormones, and the confusion in reporting the results, Sherman (1978) described cases where pregnant women had received injections of progesterone in order to prevent miscarriages. Progesterone is a naturally occurring hormone of pregnancy. Some of these patients' daughters had been fetally "androgenized" and masculinized; they were later found to have unusually high IQs. Although androgenized by a female hormone, the high IQ results were later reported to be a result of male hormones. Sherman also reported that the normal sisters of those affected girls had high IQs; Sherman felt this was a result of the more sophisticated level of the families involved, rather than the kind of sex hormone present.

Hormonal Theory

The best known theory concerning a hormonal basis for male/female cognitive differences was proposed by Broverman, Klaiber, Kobayashi and Vogel (1968) and is referred to in the literature as the Broverman theory. The males selected for study were chosen on the basis of physical characteristics which indcated a high androgen level (greater shoulder and chest width as compared to height, more extensive hair on the chest, and an above average excretion of one of the breakdown products of testosterone). These subjects were found to have superior performance on simple, automatic tasks. From these findings, the authors postulated that male and female sex hormones affect intellectual performance by interacting differently with transmitter substances in the brain; this differential interaction resulted in a higher level of skill on either "Type A" or Type B" tasks, depending on the individual's sex.

Basis of the theory. The basic premise of the Broverman theory is that females perform better than males on simple, overlearned perceptual-motor tasks, such as clerical tasks, field dependence tests, verbal fluency and rote learning, which Broverman classified as Type A tasks. Performance of these Type A tasks depends on an activation of the central nervous system. In contrast, males surpass females on the more complex "perceptual restructuring" Type B tasks, such as tests of field independence and embedded figures, which require an inhibition of the immediate reponse to an obvious stimulus. These male/female differences were attributed to a differential effect on the brain of androgens and estrogens. Broverman et al. hypothesized the excess amounts of either estrogens or androgens tended to predispose the nervous system towards activation (and skill at Type A tasks) rather than inhibition (and skill at Type B tasks). However, they believed estrogens to be more powerful than androgens in this respect. This accounted for a greater female predisposition toward activation and Type A skills, which left males with a superiority on Type B tasks.

Criticism of the theory. The Broverman theory has received wide criticism and very little empirical support. Parlee (1972) found fault with the characterization of tasks in which women excel, a characterization that selectively omitted those tasks not fitting Broverman's basic premise on the nature of the sex differences. Parlee, as well as Sherman (1978), felt that verbal ability could not be regarded as a simple, over-learned, perceptual-motor task. Although Broverman et al. (1968) characterized restructuring as the chief difference between the tests which differentiated the sexes, Maccoby and Jacklin (1974) have pointed out that females generally do better than males on anagrams, which is a restructuring task. Maccoby and Jacklin also pointed out that the classification of tasks into Types A and B does not prove useful for making sense of the observed male/female differences in cognitive style. They contend there are not consistent sex differences in tasks requiring inhibition of learned responses or in those requiring overlearning and repetition.

Two subtests from the Wechsler Adult Intelligence Scale (WAIS) were used by Broverman et al. (1968) to demonstrate male/female cognitive differences: the Digit Symbol as a test of simple repetition and the Block Design as a test of complex spatial restructuring.

Sherman (1978) reported that using omega squared to measure the extent of the differences indicated the following: the differences between the sexes that the Broverman theory attempts to explain actually accounts for an extremely small percent of the variance on those tasks. (See Chapter Three for a discussion of omega squared.)

Sherman (1978) also criticized Broverman et al. (1964) on the grounds that no direct evidence was presented that proved the greater activating effect of estrogens as compared to androgens in humans. Sherman felt the technical difficulties and the possible confounding factors in providing adequate data for that inference were considerable. Sherman also pointed out that much of the empirical data in support of the Broverman theory was based on male subjects only, and the clearest results were obtained on adolescent male subjects. Thus the results may be confounded by maturation effects and, in addition, cannot be generalized to females.

Hormones and Spatial Ability

Harris (1978) presented a lengthy review of possible factors affecting male/female differences in spatial ability. The curvilinear relationship between spatial ability and the androgen/estrogen ratio proposed in Petersen's (1976) study of physical androgeny, cognitive functioning and adolescence was discussed by Harris. "The less androgenized male is a better visualizer and is less fluent than the more androgenized male; the more androgenized female is a better visualizer and is less fluent than the more estrogenized female. The good visualizer of either sex, therefore, is less sexually differentiated than the fluent producer" (p. 483). Harris held that spatial ability required some minimum level of androgen and gave as supporting evidence the known spatial deficits characteristic of Turner's syndrome in females and the testicular feminization syndrome in males. These two syndromes represent abnormal conditions. Turner's syndrome patients have an XO chromosome arrangement instead of XX or XY. Males with the testicular feminization syndrome are XY males whose bodies are unreponsive to androgens. It is highly questionable whether such evidence can be generalized to normal subjects.

Colwill and Lips (1978) commented on some interesting results of the Broverman et al. (1968) study

> Despite the lack of support for the Broverman hypothesis, its investigation has led to some interesting findings suggesting that sex hormone levels may be related to spatial ability. Several studies link highly "masculine" physical characteristics among males (presumably an indication of androgen level) with low spatial scores. This pattern of results is very difficult to interpret, given that male superiority in spatial skills becomes apparent only at puberty--the time when androgens are being poured into the bloodstream at a higher rate than ever before! . . . There is some evidence suggesting that sex hormone levels in the bloodstream may relate to spatial but not to other cognitive abilities. Even the results for spatial abilities, however, tend to leave one somewhat puzzled. Obviously, we must look further for an understanding of sex differences in cognitive abilities. (p. 161)

Yalom, Green and Fisk (1973), in a study of males exposed prenatally to exogenously administered estrogens and progestrogens, reported that their subjects had lower scores on the Embedded Figures Test, which is purportedly a spatial test. Those researchers suggested that the prenatal estrogen organized the brain in some female way. Sherman (1978) found several conceptual, empirical or statistical reasons why that suggestion was highly unlikely, including the facts that the subjects were abnormal and too few, the probability levels were inadequate, and the results were not replicated. Bleier (1979) discussed the effects on the developing brain of the high maternal levels of estrogen and progestins to which all fetuses are exposed. "The complexity of these research problems suggests that this is not the time for scientists and others to use such data, which at best are preliminary and, hence, often contradictory as a basis for theories about the origins of human sex roles and behaviors" (Bleier, 1979, p. 53). Sherman (1978), in an in-depth examination of metabolic and hormonal explanations for male/female cognitive differences, summarized the data

> At this point, it is probably apparent that there is very little that can safely be concluded about "sex" hormones and intellectual functioning in humans. Very few effects have been demonstrated. While the Broverman et al. (1968) theory is clearly unsatisfactory, some relations have been demonstrated between androgen levels and cognitive performance. Effects that have been demonstrated need replication and ruling out of possible confounding effects, such as socio-economic level and maturity. At such time as these effects are well-established, it will then be appropriate to devise a theory to explain them. (p. 107)

Developmental/Maturational Factors

Waber (1976) contends that discussions about the origins of sex differences have usually focused on the obvious dichotomies, such as nature versus nuture and male versus female. However, Waber feels that if the sexes are arrayed along a continuous biological dimension, this point of view might yield more information about the mechanisms of the sex differences than do the dichotomous comparisons of male and female.

One of the dimensions to be considered is maturational rate. Waber (1976, 1977) noted that females generally gain physical maturity at an earlier age than males. Waber hypothesized that maturational rate was systematically related to the mental abilities for which male/female differences in cognition have been reported, namely verbal and visual/spatial skills. She predicted that, independent of sex, early maturers whould have better verbal than spatial abilities, that later maturers would perform better on spatial tasks than on verbal tasks, and that early maturers would show less speech lateralization.

To test the predictions, Waber (1976, 1977) selected 40 girls, ages 10 to 13, and 40 boys ages 13 to 16. The subjects were classified as early or late maturers on the basis of secondary sexual characteristics. Standardized tests of verbal and spatial ability were given, in addition to a dichotic listening test to assess speech lateralization. As was predicted the early maturers, regardless of sex, scored better on verbal than spatial tasks, and the later maturers scored better on spatial than verbal tasks. The earliest maturing group (early maturing girls) and the latest maturing group (later maturing boys) showed the greatest differences in verbal and spatial tasks, in the predicted direction. However, Waber found that only the spatial scores were systematically related to the rate of maturation; the verbal scores showed no relationship to rate of maturation. In other words, the later maturers performed better than early maturers on spatial taks, but early maturers did not perform better than the later maturers on verbal tasks.

In a further analysis of the scores Waber (1977) found that the older an individual is at the onset of puberty, the better will be his/her performance on spatial relative to verbal tasks, independent of sex or general intellectual level. Waber felt the data from the study supported the idea that rate of physical maturation is an important determinant of the male/female difference in spatial but not verbal ability. On the dichotic tasks (Waber, 1976) the later maturers showed a larger right-ear advantage (REA) than the early maturer, but only in the older group; no sex differences appeared on these measures. The group that showed a greater degree of lateralization was also superior in spatial ability. Waber believed this finding gave support to the Levy/Sperry hypothesis, as opposed to the Buffery/Gray hypothesis. Both of these hypotheses were discussed in Chapter Four.

Waber (1976) felt the results had important implications:

> 1. Since sex accounted for only a very small proportion of the variance in comparison to maturational rate, the reported male/female differences in verbal and spatial skills probably reflects a differential distribution along a physiological continuum more than a categorical difference between male and female.
>
> 2. Since the maturational rate was shown not to be related to verbal ability, the male/female differences in verbal and spatial abilities may have very different origins and cannot be explained by a common set of causes, whether environmental or physiological.
>
> 3. The rate of maturation may play an important role in the organization of higher cortical functions and may be an important determinant of male/female differences in verbal and spatial abilities. (p. 573)

Thus Waber's (1976, 1977) data led to the proposal that male/female differences in verbal and spatial ability and the lateralization of these functions may be due not to sex but to a variable that is correlated with sex--maturational rate. Additionally, developmental data reviewed by Waber (1979) purportedly shows that "such sex-related differences can be related systematically to the functional organization of the cerebral cortex . . . the verbal and spatial domains in which sex-related differences appear may develop independently of one another . . . different neurological mechanisms may underly behavioral differences in the two domains--a conclusion which may not be apparent from consideration of the data on adults alone" (p. 162).

Criticisms of Developmental Approach

It is important to note that not all research supports Waber's hypotheses. Petersen (1976) did not find a relationship between cognitive performance and early-versus-late maturers. Furthermore, since the degree of brain lateralization may be set at birth or soon afterward (Kinsbourne & Hiscock, 1977, 1978; Petersen 1976), there may be no causal relationship between maturation rate and degree of lateralization. Sherman (1978) raised the following questions concerning Waber's study:

1. The girls selected were ages 10 to 13; the boys selected were 13 to 16. If there were not differences in maturation rate for verbal and spatial skills for ages 10 to 16 for the two sexes, that procedure would have been adequate. However, Waber's data did show there were certain differences. Sherman contends those differences may have distorted some of the findings.

2. Although the Waber study is being cited as showing a relationship between degree of lateralization and rate of maturation, that relationship was not found among all subjects, only among the older subjects. Sherman contends the relationship was not with degree of lateralization of verbal function to the left hemisphere, but the absolute degree of lateralization without regard to direction.

3. The three verbal tasks used by Waber (WISC Digit Symbol, PMA Word Fluency and Stroop Color Naming) did not, according to Sherman, form a single factor. Sherman questioned how reliable those tasks are in engaging the left hemisphere as there is so much automatization in them.

4. Since Waber did not find a significant difference between the sexes in spatial functioning, there is the question of what exactly is being explained by the results. (Sherman, 1978, p. 176-77)

However, Baslow (1980) felt that an important part of Waber's work was the usage of early and later maturers of both sexes, which demonstrated that the difference in maturation between the sexes is not an all-or-none proposition. The sexes can be viewed as being "differentially arrayed along continuous biological dimensions" (Waber, 1979, p. 183-84), and many individual differences occur that may override a sex difference.

Developmental Brain Growth

Epstein (1974a, 1974b, 1978) has introduced a working hypothesis about periods of brain and intellectual growth that is developmentally oriented. From a review of 14 longitudinal studies on increases in brain weight and skull circumferences (Epstein, 1974a) and a review of 13 longitudinal and cross-sectional studies of spurt periods in intellectual growth (Epstein 1974b), it was reported that the human brain goes through definite periods of growth and rest, both physically and mentally. These spurts in brain and mind have been given the name "phrenoblysis."

Growth spurts in brain and skull occur roughly at ages 6-8, 10-12, 14-17, and possibly 2-4. Epstein (1974a) has hypothesized that these periods of large increases are uncorrelated or only weakly correlated with periods of general body growth. No evidence is given to support or disprove that hypothesis. Epstein (1974b) found mental growth spurts that correlate very well with the spurts in brain and skull size, with an especially clear low rate of growth at 12-14 years of age. Epstein (1978) gave the following information on male/female growth spurts

> The growth of brain weight and head circumference both show a marked difference between the sexes after age two years. This is clearly evident in the data taken from a longitudinal study of head circumference. Girls' head growth between ages ten and twelve years is about twice that of boys, while the situation is reversed for the growth spurt centered around age fifteen years. [p. 352] If we connect brain growth with mental growth, the question arises about the implications of a quantitative difference in brain growth during a spurt period. A simple hypothesis would be that girls need a very different and more challenging curriculum from that of boys at both ages, the input being far more intense and complex for girls around age eleven, and correspondingly less intense and complex around age fifteen. (p. 367)

Epstein (1978) suggests that a curricula developed mainly for boys could be inadequate or even harmful for girls at age eleven. Furthermore, he suggests that the failure to adapt the educational inputs to the greater capacities of girls at this age could be responsible for the relative lack of females in the more theoretical or abstract professions. Additionally, according to Epstein, the educational system may be depriving girls this age of the needed background on which to build subsequent intellectual growth. Esptein did not present data to support the hypothesis of harmful educational consequences to females as a result of a differential brain growth rates. He did caution, however, that the spurt ages and inferences therefrom referred to statistically described groups. Without further evidence no inferences should be drawn about single individuals.

Physiological/Morphological Factors

"An age-old debate about both the existence and source of a possible difference in intellectual ability between men and women may be ignited again by the first reported discovery of an anatomical difference between the human male and female brain" (Tangley, 1982, p. 422). With that statement, Tangley introduced a study by deLacoste-Utamsing and Holloway (1982) which reportedly found a sex difference in the shape and surface areas of the human corpus callosum, which is the large bundle of nerve fibers connecting the two cerebral hemispheres.

In the study deLacoste-Utamsing and Holloway (1982) examined fourteen whole, normal brains postmortum, nine male and five female. They found a male/female difference in one section of the callosum, the splenium. They reported the female splenium to be more bulbous and larger than the male counterpart, although no sex differences were found in the absolute length of the corpus callosum. This suggested to the researchers that the females' larger splenium may mean there are more nerve fibers connecting the two brain hemispheres in females than in males. This in turn, they felt, could support the hypothesis that the female brain is less lateralized, thus it is less specialized for abstract spatial tasks such as mathematics. Interpretation of this study should be mindful of the fact that the sample, although normal, was extremely small. Replications with larger samples are needed before valid statements about the hypothesis can be made.

deLacoste-Utamsing and Holloway (1982) could only speculate on the functional significance of the sex differences they found. According to the researchers, animal studies and human "split-brain" studies have demonstrated the role of the splenium in the interhemispheric transfer of visual information. The researchers state, "if we are to believe that a larger splenium implies a larger number of fibers interconnecting cortical areas and that the number of interhemispheric fibers correlates inversely with lateralization of function, then our results are congruent with a recent neuropsychological hypothesis that the female brain is less well lateralized than the male brain for visuospatial functions" (p. 1432). The following assumptions would need proof before this statement would have meaning: (a) that the number of interhemispheric fibers correlates inversely with lateralization of function, and (b) that a less well lateralized brain is a handicap for visual/spatial skills.

Concerning the size of the corpus collosum, Russell (1979) reported that the human brain, over its evolution, has undergone a steady thickening of the corpus callosum. He regarded this as evidence that as a species, humans seem to be moving in the direction of greater communication between the two halves. Russell felt that a similar phenomenon seems to be happening at the level of individual evolution; personal development of awareness is resulting in an increased communication between the hemispheres. If Russell's reasonings and the inferences drawn from the evidence of de Lacoste-Utamsing and Holloway (1982) are valid, it might then be possible to state that the female brain, as a class, is further evolved than the male brain.

Tangley (1982) related a conversation with Richard Restak, a neurologist at Georgetown University Medical School and author of The Brain: The Last Frontier (1979). Restak stated the deLacoste-Utamsing & Holloway (1982) study was significant, and should stimulate more research. "I'm not aware of any morphological sex differences in the human brain that have been found before this" (Tangley, 1982, p. 422). Contrary to Restak's statement, in 1975 Wada, Clarke and Hamm reported finding a predominance of larger right planum areas in adult female brains, although not in infant female brains. Bryden (1979) reported the findings of the Wada et al. study in a different manner. Bryden viewed it as a trend for the left planum area to be larger in adult males than adult females. To Wada et al., the finding raised the question of whether such a difference between adults and infants is developmental in nature. Additionally, Galaburda, LeMay, Kemper and Geschwind (1978) reported a Vienna study by Herschl that indicated morphological sex differences in the cerebral hemispheres. Witelson and Paille (1973) reported that female infants tended to show slightly greater asymmetry. This information on morphological sex differences in the brain, although published in professional journals, was not reported by Restak (Tangley, 1982).

Hemispheric Specialization

Hermispheric specialization, often referred to in the literature as cerebral lateralization or functional brain asymmetry, refers to the concept that for most individuals (a) the left cerebral hemisphere is specialized for language functions and the execution of learned manual activities, and (b) the right cerebral hemisphere is specialized for perceiving, constructing, and recalling stimuli that are difficult to verbalize. A very large body of clinical and experimental evidence indicates that in humans the left and right hemispheres do process information somewhat differently (Dimond & Beaumont, 1974; Milner, 1974; Sperry, 1974). Although there is general widespread agreement about the existence of cerebral hemispheric specialization, the exact nature of that specialization and its importance for information processing in the intact brain have caused considerable debate.

To complicate the argument, the possiblity of male/female variation in the nature and degree of that hemispheric specialization has attracted the attention of researchers and the public alike. In general, the most-agreed upon male/female cognitive differences appear to be in the areas of verbal and visual/spatial skills. Males, particularly after puberty, are reported to surpass females in visual/spatial skills, such as the alignment of a rod to a vertical, disembedding figures, mental rotation and point localization. (McGee, 1979; Sandstrom, 1953; Stafford, 1961; Witkin et al. 1954). In contrast, females are reported to have an advantage in verbal tasks, including speed of articulation, fluency, and grammer (Harris, 1977; Maccoby, 1966; Maccoby & Jacklin, 1974; McGuinness, 1976). It has been speculated that these male/female cognitive differences may be biologically influenced by underlying differences in how the brain is laterally organized (Harris, 1978; McGee, 1979; Maccoby & Jacklin, 1974; Sherman, 1974).

There is a divergence of opinion on at least two points: (a) the existence of meaningful male/female differences in the hemispheric specialization of verbal and visual/spatial functions, and (b) if such differences exist, whether the brain of one sex is more symmetrically organized than the other. As reviewed in Chapter Four, Buffery and Gray (1972) believe the male brain is more symmetrically organized than the female brain for both speech and spatial functions. Most reviewers find little support for this model, and instead favor just the reverse pattern (Bryden, 1979; Harris, 1978; McGee, 1979; McGlone, 1978). Fairweather (1976) disagrees with both stances, and argues that there exists no convincing male/female differences either in hemispheric specialization or in cognitive abilities.

Evidence regarding male/female differences in degree of hemispheric specialization has come from the following sources: (a) clinical studies on unilaterally brain-damaged patients, (b) normative studies on non-brain-damaged subjects, (c) anatomical studies, and (d) "split-brain" research. Each category will be briefly discussed below.

Clinical Research Studies

Clinical research on unilaterally (one-sided) brain-damaged patients rests on the assumption that the deficits observed in those patients after the occurrence of the lesion will be a valid source of information on the region affected by the lesion. Clinical studies can either (a) contrast the residual verbal and nonverbal skills after left and right brain damage, or (b) the studies can consider the functional effect separately.

In the first instance, studies by McGlone (1978) indicate that females show no significant discrepancies in verbal/nonverbal ratio scores, regardless of the side of the lesion. Males, however, show significant discrepancies in the verbal/nonverbal ratio scores, depending on the side of the lesion. In support of this finding from brain-damaged patients Bogen, DeZure, Tenhouten and Marsh (1972) also found significant male/female differences in verbal/nonverbal ratio scores with commissured patients. These three studies do tend to support the hypothesis of greater hemispheric specialization in males than in females. In the second instance, where the verbal and visual/spatial functions were studied separately, the results are conflicting, the trends are not always statistically significant, or the effects for sex show an interaction with the underlying neuropathological problem (Benton, Hannay & Varney, 1975; Edwards, Ellams & Thompson, 1979; Lansdell 1968a, 1968b; McGlone, 1977; McGlone & Kertsz, 1973).

The literature in the professional and medical journals concerning studies on unilateral brain damage is vast, technical, complex and oriented towards the clinician. It appears to have little practical application for educational policy making. The results do tend to support the hypothesis of greater hemispheric specialization in males than females for both verbal and visual/spatial functions. However, no studies have been reported that control across sex for the age, origin, extent, and location of the lesion; thus any conclusions drawn must remain very tentative. However, these tentative conclusions may find some support in the normative studies described below.

Normative Studies

While studies on brain-damaged patients are interesting and informative, they have limited applicability to the normal population. In the last two decades, special techniques have been developed to study aspects of hemispheric specialization in normal subjects. This study will briefly discuss results of two of those techniques, dichotic listening tasks and tachistoscopic tasks.

Dichotic listening. These tasks, wherein different auditory stimuli are presented simultaneously to the two ears, have shown a consistent REA (right-ear advantage) for verbally presented material such as digits, words and consonant-vowel syllables (Darwin, 1971; Kimura, 1961, 1967). A LEA (left-ear advantage) has been shown for nonverbal sounds (Kimura, 1964; Knox & Kimura, 1970). These results have been interpreted to mean the advantage of one ear over the other in identifying auditory sounds reflects a specialization of that function in the opposite (contralateral) hemisphere. But, as Fairweather (1976) has pointed out, most dichotic listening studies did not specify the sex of the subject or did not report if male/female differences were observed or analyzed.

McGlone (1980) has reviewed the studies which did report the sex of the subjects, and found the results equivocal or contradictory. It was suggested that the male/female differences may be in the peripheral auditory thresholds (rather than in hemispheric function) because males have a significantly lower right-ear threshold for middle-and high-frequency bands than do females.

Although the data tends to indicate a larger REA in males than in females for vebal material, that indication cannot be unquestionably accepted as reflecting a greater left-hemisphere specialization for language in males. Kinsbourne and Hiscock (1978) pointed out that a fundamental problem with dichotic (as well as tachistoscopic) tasks is conceptual rather than methodological. The conceptual problem is the assumption that the magnitude of listening asymmetry (as well as visual-field asymmetry) is a direct measure of the degree to which language is lateralized in an individual or in a group.

Along statistical lines, Blumstein, Goodglass and Tartter (1975) investigated the test-retest reliability of dichotic tasks. They concluded that because 29% of the subjects switched ear advantages for consonants, and 19% switched ear advantages for music, the dichotic listening procedure for investigation of ear dominance in any individual has low reliability. Teng (1981) considered the dichotic ear difference a poor index for the functional specializations between the hemispheres. Teng reported the dichotic ear differences reflects not only an ability asymmetry between the two hemispheres, but also an input asymmetry between the contralateral and the ipsilateral (same side) ear-to-hemisphere projection. In other words the dichotic tests reflect two events: (a) the difference in ability between the two hemispheres to respond to verbal or non-verbal stimuli and (b) an input dominance within the individual which directs whether the sound is transmitted first to the ipsilateral (same side) or contralateral (opposite side) hemisphere. Teng concluded that the between-individual variations in ear differences may be attributable more to variations such as input asymmetry than to those in hemispheric asymmetry. For a review and discussion of advantages and disadvantages of dichotic listening tasks see Bryden (1978), Darwin (1974) and Krashen (1977).

Tachistoscopic tasks. Using complicated equipment, tachistoscopic tasks measure visual and/or depth-perception while the eyes are fixating on one point (see Kimura, 1973, for a detailed explanation and illustrations). The visual pathways from the eyes to the cerebral hemispheres are completely crossed. Thus when the eyes are fixated on a point, all of the field to the left of the fixation point excites the visual cortex in the right hemisphere and stimuli from the right visual field excite the left visual cortex. The visual cortexes can communicate through the corpus callosum, which connects the two hemispheres.

The tachistoscopic tasks operate in the same manner as the dichotic listening tasks. That is, the ability to differentially recognize material presented to the left or the right of the central fixation point depends on whether the material presented is of a verbal or nonverbal nature. A RVF (right visual field) advantage has been shown for verbal stimuli, such as identification of words and letters (Bryden, 1965; Kimura, 1966) which is regarded as an indication of left hemisphere activation. A LVF (left visual field) advantage has been shown for nonverbal stimuli such as dot location in space (Kimura, 1966) enumeration of scattered stimuli (Kimura, 1966; McGlone & Davidson, 1973), identification of line orientation (Kimura & Durnford, 1977), and depth perception (Durnford and Kimura, 1971); this advantage is regarded as an indication of right hemisphere activation.

McGlone (1980) has reviewed recent research on tachistoscopic tasks. Many of the tachistoscopic studies of the past fifteen years have indicated a significant male/female difference for both verbal and nonverbal material, although some studies have found no differences and other studies were unable to replicate the original results. McGlone reported that those studies demonstrating a difference show a stronger LVF advantage for males in tasks presently regarded as visual/spatial tasks or right hemisphere specialization. Bryden (1978) has raised the question that the differences may reflect male/female strategy differences rather than differences in hemispheric functioning. However, McGlone (1980) points out that if strategies totally accounted for the differences, the improbable situation might exist in which women prefer to verbalize their spatial analysis but prefer a nonverbal processing for linguistic analysis.

In summary, it would appear from the present literature on tachistoscopic tasks that females might be less functionally specialized than males. However, this method of determining hemispheric specialization is not without its problems. White, (1969, 1972) critically examined the tachistoscopic findings from laboratory experiments with normal subjects and from clinical experiments with brain-damaged patients. White reached the following conclusion: much of the available evidence on tachistoscopic laterality differences and hemispheric asymmetries is ambiguous, equivocal, and inconsistent; this is attributable to inadequate methodology and misinterpretations of response indicators. Although White did not discuss male/female differences in his review, he stated the reliable evidence suggests that hemispheres do differ in efficiency to initiate specific responses and in ability to analyze and encode visual information.

Anatomical Studies

Although this is one of the oldest methods of assessing male/female differences in cognition, dating back to the 1800's, much of the earlier anatomical findings have been discounted. Chapter Two reviewed the 19th century phrenology and crainiometry investigations and concluded that those approaches were inappropriate, biased, and inaccurate.

Neural/structural asymmetries. Recent research, using advanced methods, has found structural and neural asymmetries between the two hemispheres. For details see the Physiological/Morphological section in this chapter. However, few studies have been found which report male/female neural or structural differences. Those found have been reported in the above-mentioned section. Selnes (1974) believes the cerebral commissures which connect the two hemispheres may be involved in the establishment of speech lateralization; the new findings by deLacoste-Utamsing and Holloway (1982), which reported male/female differences in the cerebral commissures, may shed further light on the subject. The possibility that males and females differ in interhemispheric connections could help to explain some of the reported functional differences between the sexes.

A basic assumption behind much of the anatomical research is that hemispheric specialization may arise when one part of the brain is larger than its counterpart. Other interpretations are possible; thus it is an open question of whether a morphological asymmetry forms the basis of subsequent hemispheric specialization, or if it is merely a reflection of another physiological happening.

Vascular asymmetries. Research has also been carried out on possible male/female differences in vascular system asymmetries as a possible link to asymmetries of the cerebral hemispheres. McGlone (1980) reviewed the technical data and concluded that since much of the data has been derived from unhealthy patients, it must be viewed cautiously.

In an area related to vascular asymmetries, the study of blood flow to the brain has shown that changes in activity in various regions of the brain appear to be reflected in the relative amount of blood flowing through those regions. Springer and Deutch (1981) reviewed studies using modern techniques to measure blood flow in normal subjects and reported small but significant hemispheric differences in blood flow to the two hemispheres during verbal and perceptual closure tasks. "As expected, the mean left-hemisphere flow was greater during the verbal analogies tasks, and the mean right-hemisphere flow was greater during the picture completion task" (Springer & Deutch, 1981, p. 94).

EEG studies. Electroencephalogram (EEG) recordings have been used to investigate hemispheric specialization in normal humans. Developed by an Austrian psychiatrist in 1929, EEG recordings were used by Galin and Ornstein in the 1960's to study the asymmetries of the brain (Ornstein, 1977, 1978; Springer & Deutch, 1981). Because they do not require an overt response from the subject, EEGs have been used to study infants and other subjects from whom it might be difficult to obtain an overt response. However, because the EEG gives a continuous measure of brain activity, it is difficult to see changes in the EEG recording that relate to specific simulus events.

In regard to hemispheric specialization and EEG recordings, Molfese (1978) found that language stimuli produced EEG patterns indicating left hemisphere activation, and nonlanguage stimuli produced EEG patterns indicating right hemisphere activation. The assumption operating here, in terms of hemispheric specialization, is that a difference in the level or pattern of electrical activity between the left and right sides of the brain reflects the extent to which each side of the brain is involved in processing the stimuli.

The concept behind the specialization of function and its connection to EEG recordings comes from a comparison of electrical activity from the left and right sides of the brain. When the brain is in a fairly relaxed state, it tends to show alpha rhythms. Ornstein (Russell, 1979) compared the relative levels of alpha from the left and right sides of the brain for different mental activities. Ornstein found that when he gave his subject a mathematical problem to solve, the alpha increased in the right hemisphere, suggesting that this side was relaxing, and decreased in the left, showing that awareness was focused more on this side. Conversely, when the subject was asked to match colored patterns, the alpha intensity increased in the left and decreased in the right, suggesting that the subject was now making greater use of the right hemisphere. This is an interesting finding, particularly regarding mathematics activating the left hemisphere. A current argument contends that males are better than females at math because they have more specialized, right-hemisphere visual/spatial skills.

Very few studies have been reported which use EEG methods to determine hemispheric asymmetry during verbal and nonverbal tasks. Those reported have been inconsistent regarding which sex is the more hemispherically specialized (McGlone, 1980). The inconsistencies may be due to the use of different types of verbal and nonverbal tasks, different modalities of presentation, and even to different placement sites for the electrodes. Additionally, McGlone raised the point that EEG recordings may be reflecting subtle male/female differences in body movements rather than the lateralization of verbal and nonvebal functions.

Springer and Deutch (1981) discussed the difficulties with EEG recordings as measures of hemispheric specialization and concluded that although it is premature to advocate their use without qualification, a body of positive findings is emerging from them that cannot be ignored. Ornstein (1978) conducted several EEG experiements with normal subjects that have added to the body of positive findings. Although Ornstein did not identify hemispheric differences by sex, he did state the results demonstrated the following

> Stories can involve the right hemisphere and spatial tests the left--if people choose to use their brains that way. It seems apparent from our research and from the work of others that the human being has a single mind and that the brain's hemispheres are not specialized for different types of material (verbal and spatial), but for different types of thought. (p. 82)

"Split-brain" Research

Historically, most of the information regarding the nature of hemispheric specialization comes from studying the kinds of functional impairments produced by asymmetric brain damage. Since the 1960's this evidence has been strengthened and extended by observations on patients who have undergone "split-brain" operations. This is an operation that eliminates direct cross-communication between the hemispheres but leaves both hemispheres otherwise intact and functioning independently. It is possible to test the cerebral hemispheres of these patients separately, and then make direct comparisons concerning the performance of the left and the right hemispheres in the same individual.

Although these patients were apparently normal under ordinary conditions, unique tests have demonstrated a whole array of distinct impairments (Levy, Trevarthen & Sperry, 1972; Sperry, 1974; Sperry, Gazzaniga & Bogen 1969). Sperry (1974) summarized these impairments by stating that "the left and right hemispheres, following their disconnection, function independently in most conscious mental activities" (p. 7).

Bogen, one of the principal surgeons and researchers in split-brain surgery in the 1960's, wrote a series of articles on the hemispheres of the brain which are regarded as classics in the medical field. Bogen held that there were two distinct modes of thought in the human brain, appositional and propositional, which he believed were largely lateralized to the right and left hemispheres, respectively. To investigate this theory, Bogen, DeZure, Tenhouten, and Marsh (1972) studied both normal and commissured subjects on two specific tests. The Similaries subtest of the WAIS was used as a verbal, left-hemisphere test, and the Street-Gestalt as a visual/spatial, right hemisphere test. Bogen et al. compared the Street/Similarities scores and derived what was termed an A/P (appositionality/propositionality) ratio. The most interesting finding was that although no significant male/female difference was found in the A/P ratio for the 1220 normal subjects, (but a cultural difference was found) a significant male/female A/P ratio difference was found in the commissured patients. According to Bogen et al., the male patients had a lower A/P ratio, meaning a greater degree of lateralization of function. The conclusion is confusing, because inspection of the data table (Bogen et al., 1972, p. 55) indicates that the females scored as high as, or higher than, all the males on the Street test, supposedly a right hemisphere test.

As is true of the above mentioned experiment (Bogen et al., 1972) all studies with commissured patients are extremely limited regarding the generalizability of the results. Those patients are few in number, and have generally had long-standing problems which could affect their testing performance. Additionally, the surgery itself could affect the separate hemispheric functions. For these reasons, studies showing male/female difference in hemispheric specialization of function, although fascinating, are insufficient evidence for proof of male/female cognitive differences.

Roger Sperry is probably the most famous of researchers in split-brain studies, and was awarded the 1981 Nobel Prize for his work in brain research. Sperry (1974) gave a detailed review of the capacities and limitations of each hemisphere and concluded that a smooth integration of the two hemispheres is more the general rule than interhemispheric antagonism. "The fact that the two separated hemispheres may each mediate conscious experience independently and concurrently does not mean that this happens under normal conditions" (Sperry, 1974, p. 18). Thus, it would appear that any male/female cognitive differences found in commissured patients may not be found in normal patients with an intact corpus callosum.

Summary

There are two other fields which could have been investigated as potential factors affecting male/female cognitive differences:

animal studies and cultural/environmental factors. Those two fields were omitted from this discussion for several reasons.

Animals generally have a symmetrical functional cerebral organization. Whether they operate from the left or the right hemisphere for specific function is more a matter of chance than of hemispheric specialization (Collins, 1968). Studies showing a sex difference in animals have generally involved the exogenous introduction of hormones. Female birds have been made to sing (Durden-Smith, 1980) and the sexual behavior of rats has been altered by manipulation of hormones (Durden-Smith, 1980; Levine, 1966).

Split-brain research with monkeys and cats (Springer & Duetch, 1981) suggests that the two hemispheres possess similar learning capabilities. There are no consistent differences favoring one hemisphere in the split-brain studies, which suggests that any differences found may be a result of asymmetrical damage from the surgery itself. Additionally, the tasks in these studies are simple and bear little resemblance to the stimuli and the tasks that reveal asymmetries in humans. The nature of the evidence in animal studies makes the generalizability of the results into human male/female cognitive differences very slender.

Regarding the second issue of cultural/environmental factors, the literature in this field is vast. An entire doctoral study could be devoted to an analysis and synthesis of the theories and data on this issue. To cover this matter adequately is beyond the scope of the present study. However, this issue cannot be ignored; it is too important. Discussion of cultural/environmental factors will be included as applicable in the chapters to follow. The cultural/environmental impact can never be disregarded in any realistic manner. The greatest problem is how to adequately and impartially assess its impact.

Concerning the other factors covered in the present discussion which potentially affect male/female cognitive differences, it is impossible to assign each a numerical value. It is quite possible that the power of each, in turn, is enlarged or attenuated by the magnitude of the presence of the other factors under consideration. The fabric of human male/female cognitive differences may, in each instance, be a unique piece of cloth, depending on the individual threads woven by the master weaver, either by caprice or design.

CHAPTER SIX
TESTS SHOWING MALE/FEMALE COGNITIVE DIFFERENCES

The purpose of this chapter is to present a narrative description of several of the standardized tests used in studies which have reported male/female difference in cognition, specifically a difference in either verbal or visual/spatial skills. The tests presented have met certain pre-determined criteria, and are considered representative of a larger number of tests available under the criteria. The tests will be described according to a specified format. It is not the intent of the present chapter to critique the tests presented at this time, but rather to present information for the reader's consumption. Each test described in this chapter is subjected to critique and evaluation in the final chapter of this study.

Rationale for Chapter Content

At least one well-known source (Maccoby & Jacklin, 1974) has reported cognitive differences between males and females, differences which the authors reported as "fairly well established" (p. 351). This evidence was gathered from research studies involving subjects of many age levels, a variety of geographical locations, and a wide range of sample sizes. Maccoby and Jacklin summarized, from 239 studies involving some aspect of verbal or visual/spatial tasking, that

(a) "girls have a greater verbal ability than boys," and (b) "boys excel in visual-spatial ability" (p. 351). Those statements have been repeated in many literature reviews and research summaries. Additionally, Maccoby and Jacklin's book is used as a basic and/or resource text in many psychology courses. Thus, statements such as these have developed a great deal of credence and are accepted as not only being derived from valid research, but also of being tested by worthwhile measures.

However, upon examining the summary tables provided by Maccoby and Jacklin, the wide variety of tests and task measures used as the dependent variable in the assessment of those two abilities is very apparent. This is particularly true in studies involving spontaneous vocal and verbal behavior and in studies of spatial (visual-nonanalytical) ability. It is also true to a somewhat lesser degree in studies involving "tested" verbal abilites. In studies involving spatial (visual-analytical) ability, for the most part the dependent variable was limited to either a standardized test or to an often-used measure such as the Rod and Frame Test developed by Witkin (1954). In the latter studies, the results were often inconsistent, although they favored males when a difference was shown. This evidence aroused an initial interest in the nature of the tests themselves and the degree of reliability and validity of those measures.

An examination of the nature of the male/female differences reported on the Porteus Maze Test determined the direction of this chapter. McGee (1979) reported that "a sex difference showing male superior performance on the Porteus Maze Test has been a persistent finding in hundreds of studies since 1918" (p. 59). Levy (1972), in a discussion of perceptual deficits, related Porteus (1965) had found that "girls were significantly inferior to boys" on the Porteus Maze test (p. 174). A curiosity as to the contents of the Maze test led to the discovery that (a) it had been used mainly on non-American populations, (b) it was "standardized" in Australia, (c) it was devised to identify mental retardates, and most importantly, (d) Porteus reported mean differences between male and female samples, but did not subject the data to further analysis. Yet Levy reported a significant inferiority for girls on the Maze test, when the test results had not consistently been subjected to a recognized test of significance, such as Fisher's t-test.

The question arises as to whether Levy looked at the test results themselves, or simply reported from Porteus's summary or another secondary source. Did Levy investigate the Maze test itself, or instead make the assumption that it was an accurate measure of perceptual deficiency? In contrast to the way in which Porteus (1965) handled the test results, a study was conducted which did carry out t-tests on the difference-scores and reported the probability levels. Vandenberg and Kuse (1978) reported significant differences favoring males on the Mental Rotations test, reportedly a group test of three-dimensional spatial visualization. Since Vandenberg and Kuse had apparently carried out the correct statistical procedures, the question again arose as to the nature of the testing instrument itself, particulary since it was one not encountered previously in the literature. Thus, the forementioned situations determined the direction of this chapter, which is an investigation of the instruments used that reportedly demonstrate male/female differences in verbal and/or visual/spatial skills.

Description of Instruments

Criteria for Inclusion

The testing instruments selected for inclusion in this chapter were limited by the following criteria:

1. The test must be listed either in a Buros' Mental Measurement Yearbook (1949, 1953, 1959, 1965, 1972, 1978), in Tests in Print (1974), or must have been or is presently in frequent usage by researchers.

2. The test must have a reasonable amount of standardization information available, presented either by the author(s), by one of the sources listed above, or by an authoritative source in the field of testing and measurement.

3. The age of the population upon which the test was standardized must fall within the age ranges of 4 years to at least 21 years.

Many tests were encountered in the literature which would fit the above criteria. From that variety, 14 representative tests were selected for presentation in this chapter. Selection was generally on the basis of frequency of use by researchers.

Format for Description

For each test included for description, the following format will be used to present the information.

1. general test format
2. specific behavior tested
3. kinds of scores provided

4. information on the normative population, such as number, age/grade, sex, socio-economic status, and geographical location
5. reliability
6. validity
7. input and output mode
8. miscellaneous information

Many of the tests considered in this chapter have a variety of subtests. In the interest of cohesion and brevity, when each subtest is described all information on that subtest will be included. In the literature, when male/female cognitive differences are reported, the differences are generally found in a specific subtest, not the entire battery. However, it is frequently impossible to obtain reliability and validity information on specific subtests. For this reason, information will be reported for the tests as a whole, with subtest information being presented as is pertinent and available.

Categories of Tests

Of the fourteen tests discussed in this chapter, the following are measures of both verbal and visual/spatial skills:

1. Wechsler Preschool and Primary Scale of Intelligence (WPPSI)
2. Wechsler Intelligence Scale for Children, Revised (WISC-R)
3. Wechsler Adult Intelligence Scale (WAIS)
4. Otis-Lennon Mental Ability Test
5. Illinois Test of Psycholinguistic Ability (ITPA)
6. Primary Mental Abilities test (PMA)
7. McCarthy Scales of Children's Abilities (MSCA)
8. Differential Aptitude Test (DAT)

The following tests are measures of some aspect of visual/spatial skills only:

1. Embedded Figures Test (EFT)
2. Group Embedded Figures Test (GEFT)
3. Children's Embedded Figures Test (CEFT)
4. Rod and Frame Test (RFT)
5. Porteus Maze Test (PMT)

The following test is primarily a test of verbal ability:

1. Peabody Picture Vocabulary Test (PPVT)

Wechsler Intelligence Scale for Children-Revised (WISC-R)

General Test Format

As with the two other Wechsler tests, the WISC-R is an individually administered test. The subtests are divided into two categories, Verbal and Performance. The first six subtests listed below comprise the Verbal category and the last six comprise the Performance category. Some of the subtests are timed while others are not. Items for some of the subtests are assigned a weighted score, the value of which depends on the nature of the answer. The examiner is allowed to probe further, particularly on the untimed verbal subtests, if it is believed the subject is not revealing all that he/she knows.

Specific Behavior Tested by Subtest

Information. This subtest measures information acquired as a result of native ability and early cutural experiences. It is considered the second best subtest measure of Spearman's g factor. Spearman was a proponent of the two-factor theory of intelligence, wherein a general factor (g) plus one specific factor per test can account for performance on intelligence tests. Spearman believed that "any intellectual activity involved both a general factor, which it shares with all other intellectual activies, and a specific factor which it shares with none" (Sattler, 1974, p. 10). The Information subtest requires memory, contains 30 items, is not timed, and requires oral input and output.

Comprehension. This subtest measures judgment or common sense and is a moderately good measure of *g*. It has 14 questions, is not timed, but is difficult to score because items are weighted. It requires oral input and output.

Arithmetic. This subtest measures reasoning ability plus numerical accuracy. It requires concentration, uses standard arithmetic operations, is a moderately good measure of *g*, contains 16 problems, and is timed. The input/output modes are oral.

Similarities. This subtest measures verbal concept formation and logical thinking and is a moderately good measure of *g*, has 16 questions, and requires oral input and output.

Vocabulary. This subtest measures ability to define words and is considered an excellent estimate of intellectual capacity, an excellent measure of *g*. It has 40 words and requires oral input and output.

Digit Span. This subtest measures attention and short-term memory, requires oral input and output, and is a supplementary subtest.

Picture Completion. This subtest measures ability to differentiate essentials from non-essentials and is a poor measure of *g*. It requires concentration, visual alertness, visual organization and visual memory. It contains 20 drawings with missing elements, is timed, and required visual input, verbal output.

Picture Arrangement. This subtest measures ability to comprehend, sequence and identify relationships by arranging pictures in sequence to provide a logically correct story. It can be used as a nonverbal estimate of *g*. It contains 11 pictures, is timed, and requires visual input, motor output.

Block Design. This subtest measures ability to manipulate blocks to reproduce predetermined designs, and the reproductive aspect of visual/motor coordination. It involves analysis and synthesis, is a useful measure of *g*, contains 10 items, is timed, and requires visual input, motor output.

Coding. This subtest measures visual/motor coordination, the ability to associate certain symbols with others and copy them on paper, and speed of mental operation and short-term memory. It is a poor measure of *g* and requires visual input, motor output.

Mazes. This subtest measures planning ability and perceptual organization, requires visual/motor control and speed with accuracy, and is relatively low in *g*. It contains eight mazes, is timed, and requires visual input, motor output.

Kinds of Scores Provided

Point scaled scores are provided for the subtests. These are added and transformed to obtain verbal, performance, and full-scale deviation IQ scores, with a mean of 10 and a standard deviation of 15. The raw scores may also be transformed to test age scores.

Normative Population

A sample of 2,200, statified for age, sex, geographic region, urban-rural, race and occupation (father) was used to standardize the WISC-R. The ages ranged from 6 1/2 to 16 1/2. The middle and upper socio-economic levels were over-represented in the sample.

Reliability

Internal consistency (split-half reliability) for the Verbal IQ is .91-.96; for Performance IQ, .89-.91; for Full-Scale IQ, .95-.96. The stability of the WISC-R (test/retest reliability) is Verbal IQ, .93, for Performance IQ, .90; for Full-Scale IQ, .95.

Validity

The concurrent validity of the WISC-R is: WISC-R and WPPSI (Wechsler Preschool and Primary Scale of Intelligence), .82; WISC-R and WAIS (Wechsler Adult Intelligence Scale), .95; WISC-R and Stanford-Binet, .73. The predictive validity of the WISC-R is high, but there is limited evidence of construct validity.

Miscellaneous

The WISC-R is the 1974 revised and restandardized version of the 1949 WISC. The Digit Span and Mazes subtests have not been normed.

Wechsler Preschool and Primary Scale of Intelligence (WPPSI)

The information provided for the WISC-R generally applies to the WPPSI with some exceptions. The WPPSI, a test for children ages 4 to 6 1/2, relies less on formal education and more on experience. The Animal House subtest is used in place of Coding, and here the child must associate certain colored cubes with specific animals and match them. The WPPSI includes the supplementary Sentences subtest, which measures the ability to repeat sentences verbatim and is regarded as a memory test. The WPPSI does not include Picture Arrangement or Object Assembly subtests. The WPPSI is the only Wechsler test to include Geometric Design, an untimed test requiring copying a circle, square, or other figures from line drawings. Geometric Design is a measure of perceptual and visual/motor organization abilities.

The WPPSI was standardized in 1967 on 1,200 subjects, ages 4-6 1/2. Internal consistency for Verbal IQ is .93-.95; for Performance IQ, .91-.95; for Full-Scale IQ, .96-.97. Concurrent validity of the WISC-R and WPPSI is .82; for the WPPSI and Stanford-Binet it ranges from .33 to .92 for the Verbal scale; from .33 to .88 for the Performance scale; and from .44 to .92 for the Full-Scale, with medians of .81, .67 and .82 respectively. The WPPSI is regarded as a more difficult test than the Stanford-Binet and thus yields a lower mean IQ by comparison.

Wechsler Adult Intelligence Scale (WAIS)

Intended as a measure for subjects 16 years or older, the WAIS has essentially the same content and format as the WISC-R with some exceptions. The WAIS, standardized in 1955, is a revision of the 1939 Wechsler-Bellevue test. It was normed on 1700 adults from New York, ages 16-64. The WAIS includes neither the Mazes nor the Geometric Design subtests; the Coding test is called Digit Symbol, and the Picture Completion test is supplementary. Internal consistency of the WAIS is .96 for Verbal IQ; .93-.94 for Performance IQ; and .97 for Full-Scale IQ. Concurrent validity is .86, .69, and .85 respectively for the three scales, and was established on 50 white male prisoners, using the Stanford-Binet.

The three Wechsler intelligence scales (WISC-R, WPPSI and WAIS) are widely used individually administered intelligence tests. Although designed for different age levels, they are similar in content and format. The evidence for their reliability is good. They have satisfactory validity although it rests on limited evidence.

Otis-Lennon Mental Ability Test

General Test Format

This is a group paper and pencil test with no subtests. It has six levels; the three lower levels require no reading. The six levels cover grades kindergarten through twelve. The test is not timed.

Specific Behavior Tested

The Otis-Lennon is not a measure of innate learning potential, but rather of learned or developed abilities. It measures broad reasoning ability which involves the abstract manipulation of ideas expressed in verbal, figural or symbolic form. It measures the verbal-educational part of *g*.

Primary I and II levels measure classification, following directions, quantitative reasoning and comprehension of verbal concepts. Elementary I level measures the same behaviors, and additionally measures reasoning by analogy. The Elementary II, Intermediate and Advanced levels measure verbal comprehension (synonyms, opposites, sentence completion, and scrambled sentences), verbal reasoning (word-letter matrix, verbal analogies, verbal classification, inference, and logical selection), figural reasoning (figure analogies, series completion, and pattern matrix), and quantitative reasoning (number series and arithmetic reasoning).

Kinds of Scores Provided

From the raw score, the Otis-Lennon provides deviation IQ's, age and percentile rank, and stanine scores.

Normative Population

The norming group was controlled for size of school, income, educational level of parents, and type and quality of school. All 50 states were represented. The number of subjects for kindergarten was 5,379; for grades 1-12, 11,866; for grade 14, 746. The sample represents the country's educational system, not the population at large.

Reliability

Equivalence (alternate forms) reliability is .83 to .89 for grades K-4; for grades 4-12, it is .90+. Internal consistency is reported as .88 to .96, and stability as .80 to .94.

Validity

The Otis-Lennon is regarded as correlating adequately with educational criteria and measures of general school aptitude. The correlation with achievement tests is .50 to .90; with intelligence and aptitude tests, .70 to .85. The Otis-Lennon is a good predictor of scholastic success.

Input/Output Modes

The Primary I and II and the Elementary I levels require no reading, and have a pictorial and geometric content. The upper three levels require reading; the stimuli is verbal, figural and numerical.

The output for all levels is visual/motor, utilizing a paper and pencil test.

Miscellaneous

The Otis-Lennon Mental Ability Test, standardized in 1970, is a revision of the Otis Quick-Scoring Mental Ability Test, the former being a marked improvement, both technically and substantively, over the latter. The Otis-Lennon can be used as a screening device with normal subjects.

Illinois Test of Psycholinguistic Abilities (ITPA)

General Test Format

The ITPA, 1968 revised version, is an individually administered test for children ages 2-10 which contains ten regular and two supplementary subtests. Each subtest is designed to minimize the demands of any factor other than that being measured. Based on an adaptation of Osgood's psycholinguistic communication model, the ITPA addresses the representational and the automatic levels of processing. It was designed to assess relative ability in understanding, processing, and production of both verbal and non-verbal communications.

Specific Behavior Tested

Auditory Reception. It assesses vocabulary through a series of yes-no questions; the input is verbal, output is nodding or saying "yes/no."

Visual Reception. It assesses memory for visually presented, categorically related sitmuli. The input is visual and verbal (from examiner) and output is motor (pointing).

Auditory Association. It assesses skill in completing verbal analogies; input and output are oral.

Visual Association. It assesses skill in completing visual analogies; the input is visual and verbal (from examiner) and output is motor (pointing).

Verbal Expression. It assesses ability to describe familiar objects orally, the scoring being based on quantity of verbal expression; the input is visual and output is oral.

Manual Expression. It assesses understanding of use of various objects and requires ability to mime use of the object. The input is visual and output is motor.

Grammatic Closure. It assesses ability to supply the correct grammatical form of a word to complete a sentence; the input is visual/oral and output is oral.

Auditory Closure. It assesses ability to complete words having one or more missing syllables, is a supplementary subtest, and input and output are oral.

Sound Blending. It assesses ability to synthesize sounds into a word, is supplementary, and input and output are oral.

Visual Closure. It assesses ability to recognize a familiar object when only part of the object is shown. It is timed, the input is visual, the output is oral.

Auditory Sequential Memory It assesses ability to reproduce a sequence of digits and requires oral input and output.

Visual Sequential Memory. It assesses ability to reproduce a sequence of meaningless designs and requires memory, visual input, and visual/motor output.

Kinds of Scores Provided

Raw scores can be converted to a Psycholinguistic Age score (PLA) for the subtests and for the composite score. A Psycholinguistic Quotient can be obtained, which is a ratio score of 100 PA/CA, and a percentile rank for average deviations can be obtained.

Normative Population

The ITPA was normed on 962 average, English speaking children, ages 2.7 to 10.1, from middle class Illinois and Wisconsin locales. The Stanford-Binet IQ score of the sample had a standard deviation of 8 (normal is 16).

Reliability

When the twelve subtests of the ITPA are multiplied by the eight age levels, 96 coefficients of internal consistency emerge which range from .45 to .96. Only nine of the coefficients equal or exceed .90. However, the composite reliability falls below .90 only at ages 5.7 through 6.1.

Test/retest reliability was computed for ages four, six and eight. These stability coefficients ranged from .12 to .50 (Visual Sequential Memory) to .70 to .83 (composite score). These reliabilties are considerably lower than the internal consistency estimates.

Validity

There is a striking absence of content, construct, predictive or concurrent validity for the 1968 revision of the ITPA.

Miscellaneous

Because of the unequal standard deviation of the subtests, neither the PLA or the PLQ scores for the subtests can be compared, as equal variance is a basic assumption of tests of significance.

McCarthy Scales of Children's Abilities (MSCA)

General Test Format

The MSCA, published in 1972, is an individually administered test for children ages 2 1/2 to 8 1/2. Eighteen subtests make up the six scales. It was designed to measure general intellectual level as well as strengths and weaknesses in a number of ability areas.

Specific Behavior Tested

Because of the large number of subtests on the MSCA and the multi-category nature of many of the subtests, the subtests will be listed as a group under the appropriate scale, and composite input-output information given there.

Verbal Scale. This scale consists of Pictorial Memory, Word Knowledge, Verbal Memory, Verbal Fluency, and Opposite Analogies. These tests measure verbal abilities, memory, ability to classify and think categorically, and general cognition. The input is either verbal or visual/verbal and the output is verbal in all subtests.

Perceptual-Performance Scale. This scale consists of Block Building, Puzzle Solving, Tapping Sequence, Right-Left Orientation, Draw-a-Design, Draw-a-Child, and Conceptual Grouping. These tests measure manipulative skills, perception of spatial relations, perceptual/motor coordination, memory, copying, self-image, ability to classify, body orientation, and general cognition. Depending on the subtest, the input can be verbal, visual, visual/auditory, or visual/verbal. The output always involves motor activity, and can include visual or visual/verbal.

Quantitative Scale. This scale consists of Number Questions, Numerical Memory, and Counting and Sorting. These tests measure quantitative thinking, ability to solve problems involving basic computations, immediate recall, and ability to count and categorize. The input is either verbal or visual, and the output is verbal or verbal/motor.

Memory Scale. This scale consists of Pictorial Memory, Tapping Sequence, Verbal Memory, and Numerical Memory. These tests measure many aspects of memory including visual, verbal, auditory, and immediate recall, as well as perceptual/motor coordination and general cognition. Input is either visual, verbal or auditory and output is verbal or motor.

Motor Scale. This scale consists of Leg Coordination, Arm Coordination, Imitative Action, Draw-a-Design and Draw-a-Child. These tests measure the developmental maturity of the arms and legs, eye preference, and visual/motor coordination. Input is either verbal or visual and output is motor or visual/motor.

General Cognitive Scale. This scale is a composite of the Verbal, Perceptual-Performance, and Quantitative scales. The only subtests omitted are Leg Coordination, Arm Coordination, and Imitative Action. This scale measures all the abilities listed above and includes all the listed inputs and outputs.

Kinds of Scores Provided

The MSCA can provide four kinds of scores: scale indexes, percentile ranks, mental age, and a general cognitive index which is a scaled score, not a quotient, although it has a mean of 100 and a standard deviation of 16.

Normative Population

The norming sample was stratified by sex, age, "color," geographic region, father's occupation, and urban-rural residence. One hundred subjects were used at each of the ten age levels. Proportions in the sample approximate very closely the 1970 U.S. census data.

Reliability

Internal consistency was computed for 15 of the subtests, and stability was computed for the remaining three tests. The reliability coefficients for the subtests ranged from an average of .79 to .88; average for the general cognitive scale was .93. The Motor Scale is the least reliable at the older age levels, with a correlation of .60 at age 8 1/2.

Validity

Predictive validity of the MSCA for achievement used the Metropolitan Achievement Test (MAT) on 31 subjects. Correlations were high for Perceptual-Performance and Quantitative scales, mediocre for the General Cognitive Scale, and poor for the Verbal, Memory, and Motor scales. Concurrent validity with the Stanford-Binet and the WPPSI (N=35) was highest for the General Cognitive Scale (.81 and .71, respectively), adequate for Verbal, Memory, and Perceptual-Performance, low for Quantitative, and very poor for Motor (.06 and .07 respectively).

Miscellaneous

The MSCA offers a general intelligence score which is comparable to those of the Stanford-Binet and WPPSI. Its advantage over the WPPSI is the wider age range it can assess. The tasks are reported to be interesting and enjoyable, the directions clear, and the standardization and reliabilty excellent.

Peabody Picture Vocabulary Test (PPVT)

General Test Format

The PPVT, published in 1959, is an untimed individually administered test for ages 2 1/2 to 18, and requires 15 minutes or less. The test consists of 150 test plates of line drawings, each with four numbered pictures which provide the multiple-choice format.

Specific Behavior Tested

The PPVT tests verbal intelligence through the hearing vocabulary. It is a receptive vocabulary test.

Kinds of Scores Provided

The PPVT yields percentile ranks, mental age, or a deviation IQ score.

Normative Population

The PPVT was normed on 4,012 white subjects in and around Nashville, Tennessee. For the 19 different age levels the number of subjects ranged from 92 to 354. Children under nine were tested individually. Those nine and older were group tested with photographic slides.

Reliability

Equivalence reliability ranges from .67 for age 6 to .84 at ages 17-18. Stability information reported from follow-up studies ranges from .54 to .88.

Validity

Concurrent validity with the WISC IQ is in the .70 to .80 range, but is lower with the Stanford-Binet. Correlations with three group intelligence tests is in the .60's. The PPVT does not correlate as highly with achievement test scores as do some group tests.

Input and Output Modes

The input is both visual and verbal, as the examiner reads a word and the subject looks at the stimulus drawings. The output is either verbal or manual (pointing).

Miscellaneous

Although not a measure of global intelligence, the PPVT can serve as a good screening device. The 6-month intervals in age grouping creates big "jumps" in the IQ table.

Primary Mental Abilities Test (PMA)

General Test Format

The 1962 edition of the PMA is a group paper and pencil test designed to measure both general intelligence and five specific intellectual factors. The five levels of the PMA are appropriate for grades kindergarten to 1, 2 to 4, 4 to 6, 6 to 9, and 9 to 12.

Specific Behavior Tested

Verbal Meaning. This subtest assesses skill in deriving meaning from words. At lower levels, input is verbal/visual and output is visual/motor. At upper levels, input is visual (reading) and output is visual/motor.

Number Facility. This subtest assesses the ability to work with numbers, to handle simple quantitative problems rapidly and accurately, and to understand and recognize quantitative differences. For the first level, input is visual/verbal; for all other levels it is visual (reading). All outputs are visual/motor.

Reasoning. This subtest, not included in the first two levels, assesses the ability to solve logical problems and requires visual input, visual/motor output.

Perceptual Speed. This subtest assesses skill in speed and accuracy of recognizing similarities. Used for only the first three levels, the input is visual, the output visual/motor.

Spatial Relations. This subtest assesses the ability to visualize how parts of objects or figures fit together, their relationships, and their appearance when rotated in space. Input is visual, output is visual/motor.

Kinds of Scores Provided

Different kinds of scores are provided for the different levels of the PMA. For kindergarten-grade one, mental ages and ratio IQ's are obtained for both the subtests and the total. For grades two to four, deviation IQ's and percentiles are obtained for subtests and the total, or mental ages and ratio IQ's for just the subtests. For the upper three levels, deviation IQ's and percentiles can be obtained for both the subtests and the total.

Normative Population

The norming population was stratified for geographic region, age and grade, but not for socio-economic status or parent's occupation. A total sample of 32,393 were obtained from 73 schools in 39 school systems. Ages ranged from four to twenty. There is not data for distribution by sex. The Great Lakes area and the West are overrepresented, while the Southeast and the Plains region are normally represented.

Reliability

No reliability data was reported for the kindergarten and first-grade level of the test. Stability coefficients for the total score was a median of .91, and for the subtests it ranged from .67 to .89.

Validity

Reported correlations with end-of-year grades ranged from .03 for Spatial Relations at grade ten to .78 for the total score at grade seven. Both concurrent and predictive comparisons with the Iowa Test of Basic Skills were made, with correlations ranging from .75 to .84.

Miscellaneous

The PMA has had an interesting history. The first version (1938) was for high school and college only, and measured seven factors. Since that time it has gone through five revisions and has descended downward in age through each. The 1958 revision was the first time the PMA was organized by grade level instead of age level.

Differential Aptitude Test (DAT)

General Test Format

The DAT is an objective group test for grades 9-12 and for adults. It is an aptitude battery with two achievement tests. All tests are power tests except Clerical Speed and Accuracy which is a speed test.

Specific Behavior Tested.

The DAT measures six basic aptitudes and two achievement variables. The aptitudes are:

Verbal Reasoning. A comprehension test utilizing analogies, it measures ability to handle complex logical relationships which can be stated in verbal terms.

Numerical Ability. A computation test embodying only arithmetic principles, it measures mental computational skill and specific educational achievement. No words are used.

Abstract Reasoning. A figural reasoning test requiring inferring a rule or principle from a series of figures, it measures reasoning ability as well as the ability to visualize spatial patterns and shapes.

Clerical Speed and Accuracy. A perceptual speed test requiring quick and accurate perception of similarities and differences, it measures the ability to scan visual materials rapidly and locate designated items.

Mechanical Reasoning. A test which requires the understanding of basic physical principles, it measures mechanical experience and the ability to visualize in two or three dimensions.

Space Relations. A test of mental manipulation, or mental paper folding, it measures the ability to visualize objects and forms in two or three dimensions.

The achievement variables are:

Spelling. This test measures recognition of misspelled words.

Language Usage. This test measures recognition of poorly formed or nongrammatical sentences as well as general verbal knowledge.

Kinds of Scores Provided

The DAT provides 23 percentile levels for the individual's profile sheet, as well as stanine categories.

Normative Population

Stratified random sampling was employed, and was based on school enrollment and socio-economic status. Over 50,000 subjects of both sexes in 43 states, from 100 school systems in all major geographical regions were selected. The high school sample was large and well chosen. There was an overrepresentation of blacks in the norming sample. Separate sex norms were established for each grade 8 through 12. No norms were established for the adult population.

Reliability

Good equivalence reliabilty has been established for the Clerical Speed and Accuracy test. Internal consistency for all other subtests ranged from the high .80's to the low .90's. This reliabilty appears to be good at all grade levels. No reliability evidence was reported for the adult population.

Validity

The DAT has high predictive validity, in each of the subtests, for academic success. The DAT has a high correlation with the General Aptitude Test Battery.

Input and Output Mode

Since the DAT is a paper and pencil group test for grades eight and above, it requires reading (visual/verbal input) and writing (visual/motor output).

Miscellaneous

The DAT is regarded as an excellent instrument for educational placement, selection, and guidance. It is considered the best available foundation battery for measuring the chief intellectual abilities and learned skills at a high school level.

Porteus Maze Test (PMT)

General Test Format

The PMT, often referred to as the Maze test, was first published in 1915. It is an untimed, individually administered paper and pencil test for ages three and over. The test consists of 12 mazes of progressive difficulty. Two trials are allowed on each maze. The materials consist of three different maze series: the Original or Vineland Series which is to be given first, the Extension Series, and the Supplementary Series. The latter two are intended as retest measures only. No manual is provided.

Specific Behavior Tested

Originally designed to test for degree of mental defectiveness, the PMT is regarded by its author (Porteus, 1965) as a measure of planning and foresight. The test requires the resolution of some moderately complex spatial relations.

Kinds of Scores Provided

The PMT is scored in two quite different ways to produce measurement of two distinct attributes. Ability scores, recorded in mental age or test quotient units, indicates the degree of success in solving the problems. Qualitative scores indicate stylistic qualities and the degree of "sloppiness" in pathway drawings. Qualitative scores are measures of test-taking behavior, i.e., impulsivity or impetuousness. Although not a general intelligence test, the PMT has been reported as a performance test of intelligence yielding test age scores which may be converted into IQ estimates.

Normative Population

The original study was conducted in 1913 in Melbourne, Australia. The tests devised for younger children were tried out in the city kindergartens and "a fairly accurate standardization for three, four, and five years was achieved" (Porteus, 1965). The test was revised and applied in 1918 to 1,255 students with equal numbers of males and females. The schools were classified as lower or middle class but no information was provided as to the numbers from each class. No norming has been done on adults. The foregoing is the extent of the standardization data available.

Reliability

No reliability data was provided by the author (Porteus, 1965) or has been reported in the literature.

Validity

A considerable number of studies have reported correlations of the PMT with a variety of ability tests involving block designs or matrices as well as with general measures of intelligence. The Stanford-Binet correlations ranged from .21 to .54. Correlations with Healy Picture Completion II was .70, with Kohs Block Design, .69, and with Knox Cubes, .75. The latter correlations are the highest correlations reported for the PMT with any other test. No content or construct validation evidence has been provided.

Input and Output Modes

Except for the instructions, the input is visual and requires no reading. The output is visual/motor; the subject draws a line through the maze course without crossing lines or raising the pencil.

Miscellaneous

The PMT has been classified as more a measure of associative than of cognitive processes. Sex differences favoring males have been consistently reported, but the differences are small. These differences will be discussed in a later chapter.

Embedded Figures Test (EFT)

General Test Format

The EFT, first used in 1950, is an individually administered timed test for ages ten and over. The test consists of 24 cards containing a complex geometric figure. The complex figures are colored to reinforce a given pattern and subpattern in order to obscure the simple figure. The subject's task is to locate a previously seen simple geometric figure which is embedded in the larger, complex figure. The subject may see the simple figure, for ten seconds, as many times as desired. No regular test manual is provided. The materials are accompanied by two papers of the author, one a research report and the other an exposition of theory (Witkin, 1950, 1961).

Specific Behavior Tested

The EFT is reported to diagnose field-independence, cognitive clarity, analytical versus global perceptual mode, and a general disposition to articulate and structure experience. The EFT tests the ease with which a person can see the figure independently of the context in which it is presented. It is not interpreted as an index of general ability.

Kinds of Scores Provided

The obtained score on the EFT is the time taken to find the embedded figure on each card. There is a five minute maximum for each card.

Normative Population

The EFT was standardized on 51 male and 51 female college students at Brooklyn College, New York. No other standardization information is available on the population.

Reliability

Standardization odd-even correlations are .87 for males and .74 for females. Witkin (see Witkin et al., 1954), author of the EFT, reported a test/retest reliabilty after three years of .89 for both men and women. Reliability coefficients from ten studies, using either odd-even, test-retest or analysis of variance methods, have reported a median coefficient of .90.

Validity

Construct validity correlations between the EFT and the Rod and Frame test ranged from .47 to .76 for males, and from .03 to .26 for females.

Input and Output Modes

The input is visual. The output is visual, verbal, and motor, as the subject is asked to describe the complex figure, view the simple figure, and then trace the simple figure with a stylus.

Miscellaneous

The EFT has not been published on a scale suitable for regular consumer use. Testing materials are available from the author (see Buros, 1978). It is not for selection or diagnostic purposes.

Group Embedded Figures Test (GEFT)

General Test Format

Published in 1971, the GEFT is an adaptation of the individually administered EFT. The test consists of a test booklet which presents 25 complex test figures plus two sample figures. Eight simple figures are printed on the back cover of the booklet; the subject is to find a specified simple figure in each of the complex figures. The subject then traces the simple figure in the complex figure with a pencil. The test is timed.

Kinds of Scores Provided

The raw score (0-18) reflects the number of simple figures correctly traced on the second and third parts of the test. No provision is made for partial scoring. There are no interpretive standards for the score scale.

Specific Behavior Tests

The GEFT is reported to measure the global-analytical dimension of cognitive functioning which is part of field independence/dependence. The test requires short-term memory for design.

Normative Population

The GEFT was normed on a small sample of subjects at an Eastern, liberal arts college (male N=155; female N=242). Although the instrument is intended for a broad age range, norming information was provided only for the college students. No other norming information was available.

Reliability

The GEFT has a correlation of .82 for the second and third parts of the test. The correlation between the GEFT and the original, individual form of the EFT are .82 for males and .63 for females, a difference which is unexplained.

Validity

The validity data for the GEFT is limited. There is a positive but low correlation with the Rod and Frame. The construct validity is reported by Witkin et al. (1954) as coming from twenty years of research.

Input and Output Modes

Input for the GEFT is visual. Output is visual/motor and involves outlining with a pencil.

Miscellaneous

The present test is regarded as preliminary and is intended for research purposes only.

Children's Embedded Figures Test (CEFT)

General Test Format

Designed for ages 5 to 12, the CEFT is a revision of the Goodenough-Eagle modification of the EFT. The test is a series of items which require the subject to find a simple form in a complex one, but uses meaningful complex forms to make the task attractive. In the eleven-item "tent" series, a tent-like simple figure is embedded in a stimulus figure. The test also includes a similar fourteen-item "house" series.

Specific Behavior Tested

The CEFT is designed to measure an individual's field independence/dependence. This dimension, more recently labeled as psychological differentiation, is manifested in cognition by global versus analytical cognitive structuring, and in perception by field independence/dependence. Specifically, it measures the ability to disembed a simple figure hidden in a complex figure.

Kinds of Scores Provided

The score represents the total number correct on both series of the test, "tent" and "house."

Normative Population

The only normative information available is that the test was standardized on males and females, ages 5 to 12.

Reliability

Internal consistency has been reported from .83 to .90. A study subsequent to the standardization showed a stability correlation of .87 between kindergarten and first grade scores.

Validity

Concurrent validity with the EFT is reported as follows: .83 to .86 for ages 11-12; .70 to .73 for ages 9-10. The lower validity for the older age group resulted from the fact the EFT has an r of .75 at age nine, but it is .90 at age 11. No construct validity information has been reported.

Input and Output Modes

The input is primarily visual, except for directions from the examiner. The output is visual/motor.

Miscellaneous

The CEFT is a satisfactory downward extension of the EFT and is valuable in research on psychological differentiation. The utility and value of this dimension is a separate issue from the CEFT research instrument, however. This can only be determined by further research and by construct validation.

Rod and Frame Test (RFT)

General Test Format

The RFT, an individually administered test, is given to a seated subject in a completely darkened room. The subject is led in blindfolded. An illuminated frame enclosing an illuminated rod is seven feet in front of the subject. The chair may be tilted 28^{0} to the right or left, and the rod as well as the frame may be independently tilted by the examiner. The standardization test consisted of twenty-four trials in sets of eight; each of the three sets were given over several months time. In sixteen trials, the chair was tilted to either the same or the opposite side of the tilt of the rod.

Specific Behavior Tested

Described as a test of space orientation, the RFT tests the perception of position, in relation to the upright, of an item within a limited visual field under various conditions. For successful performance, the subject must "extract" the rod from the tilted frame through reference to body position. On each trial, upon opening his/her eyes, the subject describes the positions of the rod and the frame. On all trials, a large actual tilt of the rod when it is reported by the subject to be straight indicates adherence to the visual field; a small tilt indicates independence of the field and reliance on the body.

Kinds of Scores Provided

The scores provided are the deviations, in degrees, of the rod from the true vertical. The score is based on the average of eight trials in each series.

Normative Population

The RFT was normed on 52 male and 51 female volunteers from an introductory psychology class. The average age for the males was 21.2 and average age for females was 19.6. These subjects were randomly selected from a large population of 211 scoring in 11 pre-set score segments. In addition, a younger group of subjects from age groups 9, 10, 13, 15, and 17 were selected; 30 males and 30 females represented each age group. The subjects were either from Brooklyn College in New York or from schools in New York City.

Reliability

Equivalence reliability is reported from .52 to .59 for males, and from .47 to .56 for females. Test-retest reliability ranges from .56 to .90 for males and from .29 to .88 for females. Much of the reliability information is from later studies or from additional data gathered after the standardization study. There is a high test/retest reliability for the five week, one year and three year intervals.

Validity

Correlations between the RFT and the EFT range from .43 to .76 for males and from .03 to .26 for females.

Input and Ouput Modes

The input is visual. The output is verbal and visual. The subject describes to the examiner the position of the rod and the frame on each trial. The examiner is able to tilt the rod, the frame, or both. The subject tells the examiner to stop tilting the rod when it appears vertical, regardless of the position of the frame.

Miscellaneous

The RFT is the only test of those reported in this study which was not listed or reviewed in any Buros (1949, 1953, 1959, 1965, 1972, 1978) yearbook. Although it did not fit this important criteria , the RFT was included because it is frequently encountered in the literature as a test which demonstrates evidence of male/female differences along cognitive as well as psychological dimensions. Thus it was decided the test was worthy of consideration and investigation.

Summary

This chapter has presented a descriptive review of a variety of measures of cognitive abilities. These types of tests were selected for review because of their use in research studies which have reported male/female cognitive differences. Those reported differences, using the reviewed measures, appear to be found particularly in the areas of verbal and visual/spatial skills.

The tests considered for review were selected because they either met certain preset criteria or because they were frequently reported in the literature, or both. One test, Mental Rotations, was not included because it was not listed in Buros or in any standardized assessment book consulted, although the authors (Vandenburg and Kuse, 1978) reported significant differences for males and females. Although the Mental Rotations test has been used in several studies of male/female differences in visual/spatial ability, the lack of standardization results in extremely low generalizability, as well as faith in its reliability and validity.

The tests selected for investigation were fairly equally distributed over the age range under consideration, i.e., from age 4 to at least 21. The tests were reasonably well divided between those that measure visual/spatial skills specifically (for a range of ages) and those that reportedly have the capacity to measure many aspects of either developmental factors or cognitive functioning, including both verbal and visual/spatial skills. The tests selected do not represent an all-inclusive field. Rather, they were representative of tests popularly used and/or available.

Descriptions of the tests reviewed reveals a great variety along many dimensions, including standardization procedures, validity, reliability, general format and specific behavior the test is reported to measure. The test information presented here is further analyzed and evaluated in the concluding chapter of this study. The objective of the evaluation is to provide the research consumer with a list of testing instruments that are, at a minimum, adequate measures of verbal and/or visual/spatial skills.

CHAPTER SEVEN
CONCLUSIONS REGARDING MALE/FEMALE COGNITIVE DIFFERENCES

The concluding chapter of the present study is organized into three parts. The first section provides a summative evaluation of the tests reviewed in Chapter Six. Conclusions drawn regarding each testing instrument will result in suggestions for test users and research readers. The purpose behind the suggestions is to provide a listing of test instruments which can be regarded as adequate measures of the two cognitive areas under consideration, verbal and visual/spatial skills.

The second section of this chapter reviews and synthesizes the information impacting on measurement of cognitive differences, information which was provided in Chapters Two, Three, Four, and Five. In instances where it is applicable, the review information will be tied to current thinking concerning measurement of male/female cognitive differences. This provides the reader with a cumulative state-of-the-art view of current thinking and practices in this one area of the cognitive domain.

This study does not present itself as the final word on cognitive differences. Additional follow-up work needs to be carried out. Thus, the third section of this chapter presents recommendations for further research in the area of male/female cognitive differences.

Evaluation of Tests Reviewed

Wechsler Intelligence Scales

The three Wechsler intelligence test scales (WPPSI, WISC-R, and WAIS) are among the most popular and most frequently used measures of cognition. An overlap in ages exists among the three tests. The WISC-R overlaps with the WPPSI for the age period 6-0 to 6-7, and overlaps with the WAIS for the age period 16-0 to 16-11. These overlaps can be helpful in retesting situations. Additionally, the three tests have a high degree of concurrent validity with each other.

Each of the three Wechsler scales have high degrees of reliabilty, particularly for the Full Scale IQ. Although high in reliability, the Performance IQ has the lowest reliability of the three IQ's provided. Together, the three Wechsler scales cover the age range of 4 years through late adulthood. For an in-depth discussion of the Wechsler scales, consult Sattler (1974). For split-half reliability information on each of the subtests of the three Wechsler scales, consult Salvia and Ysseldyke (1978).

Disadvantages. The WPPSI (a) requires a long administration time, (b) has a limited floor and ceiling (IQ range of 45 to 155), (c) presents difficulties in scoring some subtests and, (d) has minor administration problems. The WISC-R's limitations are (a) possible limited applicability of norms for ages 6-0 to 6-3 and ages 16-8 to 16-11, (b) limited range of IQ's (40 to 160), (c) nonuniformity of scaled scores, (d) problem of culturally biased items, (e) difficulty in scoring some subtests, and (f) difficulty in interpreting subtest scores and profiles. According to Wechsler (1958) the WAIS has low reliabilities in many of the subtests. However, Salvia and Ysseldyke

(1978) consider it adequate in comparison with the other two Wechsler scale subtest reliabilities. Additionally, the WAIS was normed only on the population from New York state, although the sample was supposedly representative of the U.S. population, and was validated on a very select prison population. Thus, its generalizability may be somewhat limited.

Bias in tests. Male/female differences have been found on some of the WPPSI subtests. In the standarization sample, girls obtained higher scores on the Animal House, Geometric Design, Block Design, and Sentences subtests, while boys scored higher on the Mazes subtest. "Thus, Performance IQ's may be achieved in different ways by boys and girls" (Sattler, 1974, p. 210). Wechsler (1958) reported male/female differences on the WAIS. The forerunner of the WAIS, the Wechsler-Bellevue, revealed small but positive sex differences on Full Scale scores in favor of female subjects in the original standardization data. Subsequent standardizations reversed this in favor of males.

Wechsler reported the male/female differences were small but systematic and favored males on the Verbal, Performance, and Full Scale scores. On WAIS subtests, males had a higher critical ratio score on Information, Comprehension, Arithmetic, Picture Completion, and Block Design. Females had a higher score on Similarities, Vocabulary, and Digit Symbol. No differences were reported for Digit Span, Picture Arrangement or Object Assembly. The question arises as to whether (a) some of the tasks are easier, or (b) whether the test has a built-in bias favoring one sex or the other.

However, Sherman (1978) looked at the extent of the male/female differences in the standardization sample for the Block Design subtest of the WAIS, a subtest on which males scored significantly higher. Sherman regards the subtest as a highly respected test of spatial visualization. When the data were submitted to omega squared (a measure of the extent of the differences), it was shown that sex did not account for even 1% of the variance. This finding might also hold true for the other subtests reporting male/female differences in the standardization sample, and thus would negate the suggestion of male/female bias.

Conclusions. Because of their high reliabilty, adequate validity, careful standardization procedures and test development, the WPPSI, WISC-R, and WAIS are considered at least adequate measurement instruments of cognition. Because each subtest measures a somewhat different aspect of what Wechsler termed "global intelligence" (Sattler, 1974, p. 152) and each subtest varies in degree of reliability, care should be taken in drawing conclusions about results from the use of one subtest. Additionally, there may be built-in male/female biases in some subtests of the WPPSI and WAIS. For an in-depth analysis, consult Sattler (1974) concerning the WISC-R and WPPSI, and Wechsler (1954) concerning the WAIS.

Otis-Lennon Mental Ability Test

The Otis-Lennon test is regarded as an excellent group test of the verbal-educational half of Spearman's *g*. The norming procedures are considered outstanding. The test has very high reliability and very good validity. Because it is considered a test of learned or developed abilities, results should be interpreted with that in mind. This would be particularly true of results demonstrating a male/female difference, as the findings are most likely a reflection of learning and differential experience rather than innate capability. The Otis-Lennon should not be confused with the Otis Quick Scoring, its predecessor, as the latter is not as adequate as the former. The Otis-Lennon could be considered a credible test of learned or developed behaviors. It could be used to measure learned male/female differences in solving abstract reasoning problems of a verbal, figural, and symbolic format.

Illinois Test of Psycholinguistic Abilities

As evaluated by Salvia and Ysseldyke (1978) the ITPA has inadequate norms, unestablished validity, and subtest reliability which is adequate for experimental work only. Lumsden (cited in Buros, 1978) spoke out even more strongly against the ITPA, stating it should not have been published, at least in its present form. Lumsden summed up his assessment of the ITPA with the following statement.

> My testing colleagues do not all agree that the arguments presented are cogent reasons for abandoning ITPA. One of them said: "Look, I know that test has many weaknesses. But I don't care that it is unreliable and is of unknown, and probably low, validity. I don't give the test in the standard manner and don't even score some of the subtests. ITPA represents for me a richly varied set of tasks which I use to give me hunches for further exploration. There is such a thing as clinical intuition." For testers who like to use tests in this way, may I recommend the matchbox test. With a box of matches and some ingenuity, it is possible to give rapid tests of information, motor coordination, the Bender-Gestalt, memory for designs, arithmetic, number series, progressive matrices, and even the Rorschach. Used in the clinical intuition mode, ITPA is an expensive and inferior substitute for the matchbox test. Used in the more professional psychometric mode, it is an expensive and inferior substitute for the Stanford-Binet and the WISC. (section 431)

Wiederholt (cited in Buros, 1978) reviewed the ITPA and concluded the abilities measured by the ITPA lack any empirically demonstrated educational significance. It is not regarded as a good measure of language. The ITPA has a narrow, limited norming population. Thus, until the ITPA is subjected to further research, it cannot be regarded as an adequate test when considering male/female cognitive differences.

McCarthy Scales of Children's Abilities

The MSCA is regarded as a well-standardized and psychometrically sound measure of cognitive ability of young children. Reliability is high, except for the Motor Scale at older ages. The evidence for validity is limited, but reasonably high for the General Cognitive Scale. The MSCA can assess abilities over a wider age range than can the WPPSI. Disadvantages of the test are (a) it requires a highly trained examiner, and (b) with 18 separate tests, the MSCA is lengthy. Salvia and Ysseldyke (1978) believe "it is only a matter of time before the MSCA becomes one of the most popular tests for assessing the abilities of preschool children" (p. 245). Although the test needs more extensive validation, it can be regarded as an adequate measure of cognition. Studies reporting male/female differences on subscales of the MSCA should be evaluated in the light of the differential reliabilites of the subscales for different ages (see Salvia & Ysseldyke, 1978, for subscale reliabilities chart).

Peabody Picture Vocabulary Test

The PPVT is a short, simple, convenient test of verbal intelligence which is adaptable to group testing. Reliability for the PPVT is average to moderately high, but validity is not well established. Although a verbal test, the PPVT requires visual perception, association, and meaning as part of the input. This may affect the results as the test calls on two different processes. The most serious drawback of the PPVT is the restrictive standardization sample. Salvia and Ysseldyke (1978) stated that "in essence . . . the examiner is left with an interpretation of the student's performance relative to white children in Nashville, Tennessee" (p. 251). Although a quick screening device which can be used by non-professionals, the PPVT is not recommended for consideration when examining male/female cognitive differences.

Primary Mental Abilities

Although the norming sample was large and appears to be adequate, according to Quereshi (cited in Buros, 1978) the most glaring fact about the norms is the consistent disregard for presenting data by sex or demonstrating the insignificance of the male/female differences on the abilities involved. Evidence from a study by Herzberg and Lepkin (1954) reinforces the conclusions drawn by Quereshi. The PMA does appear to reveal male/female differences, although there are not separate norms for the two sexes. Interestingly, there were no male/female differences shown on the numbers subtest for the 1,049 high school students in the Herzberg and Lepkin study, but females scored significantly higher in Verbal Meaning and in Reasoning at age 16. They scored significantly higher in Word Fluency at all three ages tested. Males in turn scored significantly higher on the Space test at all three ages tested.

Even though the reliability indices for the total scores are reasonably high, for the individual factor scores they vary considerably from one grade to another, and are extremely low in many cases. Generally, the Perceptual Speed and the Spatial Relations factors were the most unstable. Predictive validity was extremely poor for Spatial Relations at grade ten (.03). This subtest has been used in studies which have demonstrated male/female differences. For example, McGee (1979) reported a high critical ratio favoring ninth grade males on this subtest, the only PMA subtest where males had a higher critical ratio mean score than females. The credibility of that result could be questioned because of the possible bias, favoring males, on that subtest.

There is little evidence that the PMA is a good indicator of differential ability at any level. It helped to advance the multiple factor notion of ability, but has not helped with the practical side of differential educational measurement. Compared to other batteries available, the PMA is considered outmoded. It is not recommended as a test to consider when investigating male/female cognitive differences.

Differential Aptitude Test

The subtests on the DAT are considered to be "excellent in format, item construction, standardization, validation, and just about every other aspect which is regarded as important in the testing fraternity (Carroll, cited in Buros, 1959). There is a question as to whether the DAT is truly differential, i.e., do the tests actually measure different abilities? For both males and females and for all pairs of tests, only about 37% of all possible differences are beyond those expected by chance, and intercorrelations between the tests range from .06 to .67.

Although separate male/female norms are provided for grades 8-12, the differences are not large for all subtests. One of the subtests, Mechanical Reasoning, is considered relatively unreliable for girls. Mastie (cited in Buros, 1978) noted

> The mechanical reasoning test shows only one female in a featured role, and she is passively sitting in a wheelchair. All active, strong, mechanical "doers" are male. There is absolutely no excuse for this sexism, and I believe that the psychological effect may well account in part for the lower scores of females. (p. 663)

Occupational decisions, for students in general, and for males/females differentially in particular, should be approached cautiously when using DAT scores, as the tests have a high intercorrelation in some instances. Thus it might be difficult to determine what is measured by each subtest. Although it is regarded as one of the best batteries at the high school level for educational guidance and placement, the DAT may not be an accurate determiner of male/female differences for the abilities it measures. Because the DAT shows male/female differences on some subtest scores, the question arises, as it did with the WAIS, whether the test is biased against one or the other sex, or whether it is a true measure of male/female differences. This question needs to be addressed by one well-schooled in psychometric measures. The resolution of this question is beyond the scope of the present study.

Additionally, since no norms exist for the adult population, the test cannot be reliably used for that population. Since the DAT measures learned skills as well as abilities, male/female differences appearing on the test must be viewed in the light of potentially differential experiences. The DAT should be used very cautiously when investigating male/female differences.

Porteus Maze Test

As discussed in Chapter Six, interest in the PMT was brought about, in part, by McGee's (1979) statement that "a sex difference showing male superior performance on the Porteus Maze Test has been a persistent finding in hundreds of studies since 1918" (p. 59). Added to this interest was the statement by Levy (1972) that females were significantly inferior to males on the PMT. The most informative source concerning the PMT is the test author's own book (Porteus, 1965). Among other purposes, the book serves as manual, test describer, and the major source of information on research studies concerning the PMT.

McGee (1979) held that the PMT "has become as important and widely used testing device within the discipline of psychology" (p. 59). McGee presented, as evidence of this and the above statement, tables of scores for males and females on the PMT, taken from the Porteus (1965) book.

Data management on PMT. A close examination of the information presented in the tables and the descriptive information presented by Porteus (1965) reveals quite a different picture. The alleged male superiority on the PMT was based on mean difference scores. No further tests of significance, such as Fisher's *t*-test were reported in the tables. However, there are some curious leaps of logic by Porteus in his attempts to explain the results. Believing that the environmental argument, i.e., the influence of culture and socialization on male/female score differences, fails to hold up "since the differences in male mean scores are in most cases greater than the sex difference reported" (p. 127), Porteus unwittingly left himself open to criticism.

The basic premise of analysis of variance (ANOVA) is that differences in the between-group means must be significantly greater than the differences in the within-group means in order for the results to be considered significant (see Olenjnik, Note 2). ANOVA is an extension of the Fisher t-test. It would appear that Porteus has inadvertently suggested ANOVA, although, as will soon be seen, he has gone to some length to discredit the t-test.

Of the 105 PMT studies reported in his tables, Porteus performed t-tests on the 18 studies in which provision of the standard deviation allowed him to apply the formula. The results are most interesting. Only 4 of the 18 studies analyzed had a probability <.05; 9 studies has probability levels ranging from p<.14 to p<.46. Two of the studies has p<.50, which puts the results at the chance level. In Porteus' own words "the above array can only be described as showing a most bewildering disparity among t-test significances" (p. 128).

Replications with PMT. Porteus proceeds to explain that all the reported t-tests apply to (a) the same subject of investigation (not so because some are Japanese-Hawaiian, or Chinese-Hawaiian, or Hawaiian, while others are either Indian or Australids), (b) the same examiner for each group, (c) individuals in the same age groups (not so, as the age groups ranged from 9 to high school, with 3 unknown age groups), and (d) individuals attending the same schools (it is very difficult to understand how rural Indians can attend the same school as Hawaiian high school students). Porteus further states that all the results (presumably the mean differences) point to the same fact of male superiority in the PMT. (Hang in there because the plot, like the stew Porteus is in, thickens.) Reflecting on the t-test results, Porteus states

> The trouble is that the formula pays no attention to agreement among replicated investigations. For example, 11-year Chinese and 11-year Japanese are attending the same schools [not school] and are probably [added emphasis] of the same educational and social grade, yet the significance of the one comparison is p<.16, of the other p<.5. Such a

> disparity surely justifies the sign "Beware of the t-test" to protect the unwary student--a warning commonly used to advertise the danger from an untrustworthy canine. (p. 128)

It would appear that Porteus has ignored a basic principle of replication, i.e., that the population used for replication is the same as in the original study. He is comparing two distinct ethnic and cultural backgrounds and declaring one to be a replication of the other.

Probability and the PMT. Another apparent flaw in his discussion of the results is Porteus' interpretation of the *t*-test in relationship to his studies. Porteus states

> A Fisher t-test of 0.01, if I am correct, means that the chances are better than one in a hundred that the real difference is more than zero. In this instance, the writer does not need to depend on the Fisher t-test to tell him what the probability in one hundred comparisons would be. He has carried out his experiment one hundred times and the result is that in 99 out of 105 studies males were superior, or about 94 chances out of 100. (p. 136)

From the foregoing, it appears that Porteus does not understand the basic premise of the probability figure. The calculation of probability rests on the assumption that the same, identical test situation was theoretically carried out 100 times. That is not the same interpretation posited by Porteus, that of carrying out 100 different experiments, and because they show a difference, considering it a demonstration of the probability of the real difference.

Conclusions. Aside from the problems inherent in Porteus' interpretation of the results, the PMT is supported by meager information about kindergarteners in Australia upon whom the original study was standardized. No norms have been provided for adults. Reliability information is not available. Concurrent validity with the Stanford-Binet is low. Doctor (cited in Buros, 1972), in an extensive review of the PMT, concluded that after over 50 years of research on the test it can be recommended only for research purposes.

In addition, the integrity of the data base concerning male/female cognitive differences would be better served if well-known researchers such as Levy (1972) checked out the basic research before making blanket statements about the significant inferiority of females to males on the PMT. Stated quite simply, the results have not been submitted to any tests of significance, and because the PMT has been performed on wide-ranging populations, and has such poor norming and reliability data, the results themselves are suspect. In any case, it is not a test recommended for inclusion concerning decisions about male/female cognitive differences. It appears that the PMT does measure some attribute not measurable by other instruments. It remains for further research to determine the nature of that attribute.

Embedded Figures Test

Developed by Witkin, Lewis, Hertzman, Machover, Meissner and Wapner (1954) and standardized on a very small, selective sample, the EFT lacks, first and foremost, generalizability. Additionally, the specific behaviors the test is intended to measure (among them analytical versus global perceptual mode) and the male/female differences in the reported results are contradictions in terms. Reportedly, males score higher than females on the EFT, thus males might be considered as more analytical as opposed to global. Yet, if one considers the EFT as a test of visual perception, i.e., a right-hemisphere skill, (which is considered a stronger male-than-female domain), then the EFT is a global rather than an analytical measure.

The apparent contradiction leads into the more basic question of how one hemisphere can serve two bi-polar masters? In other words, if the EFT is a test of analytical perception, why do males score higher on this test when analysis is considered a left-hemisphere domain, and females are generally regarded as more left-hemisphere dominant? Why do females exhibit a more field-dependent, i.e., a more global rather than analytical approach on this test when the global/gestalt approach is considered a right hemisphere function and males are regarded as more right-hemisphere dominant?

In addition to the conceptual problems of the EFT, the test has very limited generalizability because of the extremely select standardization population. The test does appear to have very adequate reliability coefficients. The sole validity information is based on correlations with the Rod and Frame Test, a space-orientation test developed around the same time by Witkin et al. (1954), and probably normed on the same population as the EFT. Even then, the validation is extremely poor for females, ranging from .03 to .26. The validity correlations are average to moderate for males, ranging from .47 to .76, indicating that even for males, the tests do not measure the same attribute in all cases.

Further, since the EFT is not published for wide distribution, is not for selection or diagnostic purposes, and has very questionable validity and generalizability, its use for making decisions about male/female cognitive differences is not advised. Additional research, using instruments other than the Rod and Frame Test, is needed to validate the construct the EFT allegedly measures.

Group Embedded Figures and Children's Embedded Figures Tests

The problems discussed with the EFT are, in the main, also applicable to the GEFT and the CEFT. It is suspected that the GEFT was normed on the same college population as the EFT, although that is not apparent from the literature. Reliability on the GEFT is 20 points lower for females than males. Validation data, although low, comes from correlations with the Rod and Frame Test. Although the CEFT was normed on children 5 to 12, little is known about that group. The CEFT does have high internal consistency; the concurrent validity with the EFT is fairly high.

As was stated in Chapter Six, even though these three tests measure what Witkin, Dyk, Faterson, Goodenough, and Karp (1962) termed psychological differentiation, the utility and value of this dimension is a separate issue from the research instrument, and can only be determined by further research and by construct validation. At the present time, these three embedded figures tests are considered preliminary and primarily for research purposes. They are not recommended as decision aids concerning male/female cognitive differences.

Rod and Frame Test

Critical reviews were not available on the RFT from such sources as Buros (1949, 1953, 1959, 1965, 1972, 1978) or Tests in Print (1974). The major source of information on the RFT comes from the Witkin et al. (1954) book on studies in perception.

Artifacts of measurement. Sherman (1978) believes the RFT is a good example of artifacts of measurement, those uncontrolled factors which would affect a test's reliability. Since the test is conducted in nearly total darkness, social conditioning could affect female performance particularly if the examiner were male. Thus, the "same" conditions may not really be the same for males and females.

In responding to the test, the subject must tell the experimenter to move the rod until the subject thinks it is vertical. It appears that assertive behavior might be required as part of the experimental design. This could result in male/female differences, based not on differences in spatial skill but on differences in assertive behavior. Additionally, Sherman (1978) reported that "spatial tasks are sex-typed male" (p. 26). Male/female differences on the RFT disappeared when the rod was a human figure and the task was described as one of empathy, which is regarded as a female appropriate task (Naditch, cited in Sherman, 1978).

Factors involved. Sherman (1978) contends that there are several factors involved in visual/spatial perception, and there is general disagreement on how they differ from each other. One of the four factors suggested by Sherman, termed the Gestalt Flexibility by Thurstone (cited in Sherman, 1978), is called either field independence/dependence (Witkin et al., 1954) or global versus analytical cognitive style (Witkin et al., 1962). This factor, termed field articulation by Sherman, is measured by the RFT as well as by the three embedded figures tests. Thus any discussion on male/female differences in visual/spatial skill must attend to the particular factor which the instrument under consideration actually measures.

Descriptive terms. Even the terms chosen by the test authors (Witkin et al., 1954) to describe what the RFT measures is a source of confusion. Field dependence is not a logical term, since the RFT's score is based on a deviation from the vertical, whether or not the error is in the direction of the surrounding field. The score is not based on the extent to which the subject's errors depend on the field. Regarding the global versus analytical cognitive approach, Sherman (1978) felt the term "analytical" implied a generality which was not justified by the evidence. Since all the measures of an analytical approach are spatial measures, "whatever difference there may be between the sexes on these tasks appears to lie in the spatial nature of the tasks and not in their 'analytical' nature" (p. 48).

Thus, the question arises as to what is being measured by the RFT. If that question goes unresolved, how does one decide that the RFT does or does not show male/female differences when it has not been proven what differences the test truly measures? Additionally, on inspection of the concurrent validity provided by Witkin et al. (1954), the correlations for males between RFT and EFT range from .43 to .76, and are significant at the $p<.01$ level. The correlations for females ranges from .03 to .26, none of which are significant. It appears that while the RFT and EFT are validly measuring the same skill in males, that statement cannot be made for females. Thus, conclusions that the RFT shows a differential level of skill in space orientation for males and females are open to question.

In spite of this problem, the RFT has not only been cited as proof that females are not as analytical as males, but the test results have been carried over into the psychological domain and females have been regarded as having a dependent nature while males are regarded as naturally independent. It is difficult to grasp the logic of such an association, unless it can be argued that the very forces (culture, environment, socialization) that induce psychological dependency in females also affect female perception. The possiblity has not been ruled out.

Conclusions. Regarding the standardization of the test itself, the RFT was normed on a very select group. The adult subjects, although equally divided by sex, were small in number (N=103), were volunteers from a psychology class, and were selected because they were available for a 3 year follow-up period. Several threats to the internal validity of the RFT could be operating in this instance, among them (a) selection, (b) maturation, (c) testing effects, and (d) regression effects. The threats to external validity are multiple because of the population selected for study. External validity defines the limits of generalizability of the test under consideration. From a practical standpoint, all that can be said about the RFT is that it might be valid for a male population similar to the norming group, given that all other variables were held constant. In its present stage of development, the RFT does not appear to be a credible measure of male/female cognitive differences.

Tests Recommended for Consideration

The following is a list of tests recommended for consideration when investigating male/female cognitive differences. This recommendation is for the test as a composite. If a specific subtest is used in a study demonstrating male/female differences, then further caution may be warranted. Generally, the test as a composite has higher reliability than any of its subtests. Unfortunately, reliability and validity information on each test's subtest was not available for this study. Thus specific recommendations regarding subtests cannot be made in all cases at the present time.

1. The three Wechsler tests, the WPPSI, WISC-R and WAIS, are recommended for testing at ages 4-21 and over. Consult Salvia and Ysseldyke (1978) for complete information on the subtest reliabilities.

2. The Otis-Lennon is recommended for testing subjects in grades kindergarten through twelve, in those instances where measures of learned abilities are desired.

3. The McCarthy Scales of Children's Abilities is recommended for testing subjects ages 2 1/2 to 8 1/2. The General Cognitive scale score is the most reliable; the least reliable is the Motor scale at the older age levels. For a complete reliability analysis of the subtests at the various age levels, see Salvia and Ysseldyke (1978).

4. The Differential Aptitude Test is recommended with some reservation. It is regarded as the best of its kind for the high school population. However, there is some question as to its ability to measure differentially. More information than was presently available needs to be gathered on the Space Relations subtest, one that is often used to test visual/spatial skills. The Mechanical Reasoning subtest is not suitable for judging male/female differences.

A number of tests which were specially developed to measure abilities coming under the umbrella term of "visual/spaital skills" were reviewed for this study. None of those reviewed tests can be recommended at the present time for judgments regarding male/female cognitive differences. This type of test appears to have some inherent problems which have not been resolved at the present.

The nature of the problem with tests of visual/spatial skills appears to be connected with access to the cerebral hemisphere believed to host those functions. The right hemisphere, dubbed the "mute" hemisphere, is believed to have language capacity of only a very simple nature. The vast majority of measurement instruments either require or deal with language in some form. It is summized that language, which is a linear, analytical process, does not adequately tap into the non-linear, gestalt-format capacity of the right hemisphere. Even those visual/spatial tests which appear to be non-verbal in format require, in almost all instances either verbal input or verbal output. Thus a "pure" measure of the skill under consideration is not obtained. The result is tainted by interaction from the verbal left hemisphere.

Discussion of the Study

Interest in the areas of male/female cognitive differences was spawned by the national attention given to new discoveries about the functions of the two cerebral hemispheres, and to the male/female assignment of function believed to be resident in each hemisphere. The intent of this study has been to investigate the area of male/female cognitive differences and to provide state-of-the-art information on this topical issue. The format of the study has been to describe the factors related to this issue, both past and present. This section will briefly review the information previously presented.

Content of the Chapters

Chapter One. The first Chapter established the need for the study, presented the study's purposes, and defined and discussed the often conflicting terms encountered in the literature on cognition and cognitive differences. Agreement on the terms to use, as well as acceptable definitions for those terms is an important first step in establishing productive dialogue on the subject of male/female cognitive differences. Chapter One described the organizational format for the remainder of the study and briefly discussed the content of the successive chapters.

Chapter Two. The second chapter explored the historical perspectives on male/female cognitive differences, in order to examine mind-sets and psychological underpinnings which could be reflected in development and intepretation of data about those differences. The chapter highlighted the attitudes, beliefs, and written expressions of leading thinkers from the time of Plato up to the 20th century. As the investigation brought out, females' cognitive abilities have not been awarded the same high positive regard as that accorded to males. This attitudinal stance has apparently existed since the beginnings of recorded history. It is the contention of this study that such a long-standing, and thus generally accepted attitude has set the direction of research into male/female cognitive differences. It is further contended that such an attitudinal mind-set has influenced not only the procedures followed, but also the interpretation of the resulting data. Interestingly, this mind-set is not the exclusive property of males; females often have fallen prey to the sticky web spun by centuries of subtle conditioning.

An example of this conditioning can be found in the handwriting of educated females of the 18th century, when females scribed infinitesimal characters. "So unseemly was it for women to display mental capacity of any kind that when they took pen in hand to write a letter they practially obliterated what they worte" (Stannard, 1977). The behavior of those 18th century females was a reflection of established thinking dating back to the fifth century B.C., when Euripides had one of his players state, "I hate learned women" (Stannard, 1977).

Another example is that of Jane Austen, a 19th century authoress of note, who kept a large piece of muslin embroidery on her desk to cover her manuscript when people came to call. Austen was probably reflecting the feeling of the times, expressed by author Charles Lamb when he stated "a female poet, or female author of any kind, ranks below an actress" (Stannard, 1977). Needless to say, an actress was held in very low regard in the 19th century. This vignette gives an indication of the reluctance of females to demonstrate any intellectual capacity; the consequences might have been too great. This, in turn, may help to explain the question raised by Blakeslee (1980) of why there is a dearth of female "towering" geniuses. The conditions under which this capacity requires room to develop and be expressed were probably not present. It may be too simplistic to say that genius would have expressed itself regardless. That stance disallows the tremendously overriding influence of long-standing cultural conditioning.

Chapter Two looked at the powerful influence that conditioning and pre-established mind-sets can have on research design and interpretation of results, particularly the work of 19th century scientists. As Gould pointed out in the Mismeasure of Man (1981), these scientists failed to understand the built-in prejudice that led them to one interpretation out of the many consistent with the data.

Additionally, when one approach to studying the brain failed to demonstrate male cognitive superiority and female inferiority, that approach was abandoned in favor of another. The findings of these scientists, although ultimately proven to be wholly inaccurate indicators of cognitive differences, nevertheless found their way into the popular press of the day. In this manner, they became absorbed into, and part of, the cultural data base.

Chapter Two also looked at the historical association of attributes such as right, good, and positive with males and the dichotomously opposite association with females. This study contends those associations impact heavily on individual as well as societal beliefs regarding male/female differences and have recently led to a subtle tie-in of those associations with assignment of function in the brain. It is from this type of thinking that we popularize females as left-brained and males as right-brained, each pigeon-hole being trailed by an attending value.

If added together, the total impact of the dichotomous thinking plus the doubts about the mental capacity of the smaller, lighter female brain could be considerable, if not overwhelming. This study contends that such a mind-set is alive and functioning today, and almost certainly exerts an insidious but powerful influence on almost all aspects of cognitive research, from design and selection to interpretation of results. It is not often admitted, or even recognized, but this mind-set does a disservice to males as well as females. Class membership by gender can deny to males many of the valued cognitive as well as psychological attributes commonly assigned to females.

Chapter Three. Moving into the more concrete aspects of research on male/female cognitve differences, the third chapter discussed in detail the conceptual, statistical, and methodological limitations of that research. The many points covered in that discussion will not be reiterated here. The research limitations were presented in detail in the hopes that readers of such research can be aware of the pitfalls and drawbacks that can be present. The heavy social and educational weightings placed on the results of male/female cognitive difference studies makes it imperative that these limitations not be ignored. For those readers interested in instituting new research in this area, Chapter Three suggested some appropriate statistical approaches to consider which might present a clearer, fairer picture of the true differences, at least as far as the present measures are able to discern.

Chapter Four. The fourth chapter was concerned with the theories posited to explain the alleged male/female cognitive differences, particularly in the area of verbal and visual/spatial skills. The first theory discussed, variability, pertains to overall cognitive ability. Popularized by Ellis (1894) and Thorndike (1910), the variability theory holds that males are more heavily represented numerically in the tails of the distribution than females, while females cluster more around the mean and thus demonstrate more stability. This alleged greater variability of males around the mean supposedly allows males to be more heavily represented both in the genius and imbecile categories.

Witkin (1950) made an interesting comment regarding variabilty. Witkin is the principal author of the EFT and RFT (Witkin et al., 1954), two tests of visual/spatial skills which consistently show male/female differences. In discussing results on the EFT, Witkin (1950) stated "the lower value [reliability coefficient] for women reflects greater variability from trial to trial" (p. 9). If females are the more stable sex, it would appear reasonable to assume that their reliability coefficient would reflect that stability, not variability.

Another interesting piece of evidence concerning variability comes from Wechsler (1958), the developer of three well-known tests of intelligence which were reviewed in this study. Wechsler discussed those subtest scores on the Wechsler Adult Intelligence Scale (WAIS) which showed male/female differences. Wechsler graphically presented, in Gaussian curve format, the distribution of scores for both males and females. It is very evident from visual inspection of the graph (p. 149) that females, at least on the subtests in question, are the more variable. Females exhibit a flatter distribution, with greater numbers assigned towards the outer edges of the distribution. Male scores show a more narrow, mean-oriented distribution. It is interesting to contemplate the interpretations. Depending on how one views the graph, it can either prove (a) that males score higher on the WAIS than females, and thus are cognitively superior, or that (b) females exhibit more variability on the WAIS, and if variability can be regarded as a potential for greater cognitive capacity, females have the potential for greater cognitive capacity than males. Perhaps now it is easier to see how one can get wrapped around the flagpole when attempting to interpret test results, particularly through the channel of any given theory.

Recall from the discussion in Chapter Four that the 18th century anatomist Meckel believed females to be more variable anatomically than males, thus proving the stable male to be the more superior of the human species. When this theory did not give the best fit to the evidence, later anatomists held that males were the more variable sex and variability was now decreed an advantage. It appears that the notion of either greater male or female variability tends to be differentially applied. The application seems to depend on who is trying to prove what about whom. Hollingworth (1914) helped to set aside credence in this theory. She demonstrated that if social and cultural attitudes and influences were taken into consideration, males would not outnumber females in institutions for the mentally defective.

This theory is a good example of the disservice that can be done to one aspect of male attributes. Because the theory is so narrowly based in biology and has been differentially applied for at least two centuries, this study concludes that variability is an inadequate theory upon which to rest the case of male/female cognitive differences.

The next theory considered, X-linkage for certain spatial skills in males, has been fairly well discredited by considerable evidence to the contrary. X-linkage followed the biological model. Another category of theories which also follows the biological model is the hemispheric specialization theories. Generally categorized into two schools of thought regarding approach, the two main theories arrive at the same conclusions. The Levy/Sperry theory posits that males are more functionally lateralized than females, and this greater degree of lateralization accounts for differences in certain skills.

Buffery/Gray posit that females have a higher degree of functional cerebral lateralization and this accounts for skill differences. Both theories conclude that females have higher verbal skills and males have higher visual/spatial skills.

The major hemispheric specialization theories generally rest on the evolutionary theme of man as hunter and territory marker and woman as bearer and nurse of children and is offered as an explanation of differential abilities in verbal and visual/spatial skills. Harris (1978), in an amusing conclusion on the possible evolutionary processes involved in reported male spatial superiority, as a result of greater range and mobility, stated "because males appear to range farther than females even in societies that gather their food at the local supermarket, the ancestral lights may still be flickering" (p. 484).

The outstanding problem with both theories is the fact they were based on studies involving small samples of abnormal populations. Although the evidence supporting these theories is current and fascinating, the applicability of that evidence to a normal, intact brain functioning in an environment outside the laboratory is tenuous. Additional supporting evidence for these theories has come from studies using dichotic or tachistoscopic measures on normal subjects. As reviewed in Chapter Three, these measures have serious limitations and lack of generalization themselves. The hemispheric specialization theories can probably be regarded as still in a state of flux; as such, they are not recommended as bases for educational descision making. Indeed Levy, the principal developer of the Levy/Sperry theory of brain lateralization discussed in Chapter Four, appears to have done serious rethinking of the subject. In a recent issue of Educational Leadership, Levy (1983) stated

> This brief review of the roles of the two hemispheres should be sufficient to demonstrate that in the normal child or adult, both hemispheres contribute important and critical processing operations. The final level of understanding or output cannot be allocated to one hemisphere or the other. . . . Such a process cannot be accomplished by either side of the brain alone, but represents so intimate an integrative activity that, in the end, we cannot say which side of the brain contributed what." (p. 68)

In response to the welcomed turn-around in Levy's thinking, this study will borrow from a popular advertisement when it states, "Jerre, you've come a long way, baby!"

The Bent Twig theory (Sherman, 1978) is the least known of the theories reviewed, yet probably the one most applicable to educational concerns. Bent Twig acknowledges the existence of male/female cognitive differences, at least as found by present day measures. However, Bent Twig is the only theory reviewed which rests on a broader base than the biological model. Bent Twig takes into account the variety of factors and influences which can impact on the basic biological unit. Bent Twig concretizes and validates what educators have intuitively known for years about the influences operating on cognition. Educators had just not given that knowledge a title.

Chapter Five. An examination of the potentially influencing factors on cognitive development was presented in the fifth chapter. Although placed into four discrete categories, the distinction between the factors is very arbitrary. One of the basic premises of the present study is the interactive, matrix-formatted configuration into which the variables considered naturally fit. However, in the interest of categorization for ease in reading, the influencing factors were divided into (a) hormonal, (b) developmental/maturational, (c) physiological/morphological, and (d) hemispheric specialization.

The considerable amount of information presented in this study for each of the above categories was in reality a "tip of the iceberg" indicator of what is available. Each category is hotly contested both pro and con by professionals in each field of discipline. Few positively conclusive statements could be drawn from the material presented in Chapter Five, and indeed that was not the purpose of the chapter. A majority of the evidence from each discipline is in an ongoing state of development. Much more research is needed before a verdict is reached. As an example, the work by Epstein (1974a, 1974b, 1978) concerning periods of brain growth spurts appears to have educational implications. However, it was not found to be a subject well-known or discussed by even other professionals in the develomental/maturational field. Until such work is submitted to objective review by Epstein's peers, little can be concluded that might be immediately applicable to educators.

The chapter's purpose was to provide information regarding the many factors to be considered when investigating male/female cognitive differences. The purpose was not to set one variable against another as though one had merely to choose among them. Rather, the purpose was to aid in understanding the nature of the interactions operating that could affect male/female cognitive development. The interactions are extremely complex; the unanswered question is the weight given to each as a determiner of cognitive differences. After that analysis is made, a final comparison must be made against the environmental and cultural conditions that might tend to enlarge and widen individual differences.

Chapter Six. The sixth chapter of this study examined a number of the testing instruments used in studies reporting male/female cognitive differences in verbal or visual/spatial skills. Criteria was established for inclusion in the review. The one exception to the established criteria was the Rod and Frame Test; its inclusion rested on the fact the RFT has often been the instrument used when greater male visual/spatial skills were reported.

Each testing instrument was examined along the dimensions of format, behavior tested, scores provided, normative population, reliability, validity, input/output mode, and miscellaneous information. A total of 14 tests were examined. Those tests covered the specified age range of 3 through at least 21. The majority of the instruments had subtests which measured a variety of verbal and/or visual spatial skills. Four of the instruments were specific measures of some aspect of visual/spatial skill.

Chapter Six did not purport to include all applicable measures of verbal and/or visual spatial skills. Rather, a representative group was chosen for examination. The purpose of the sixth chapter was to provide a descriptive analysis of a variety of instruments used as measures of male/female cognitive differences. The intent of the description was to guide the reader's judgment of research studies concerned with this area through greater familiarization with typical instruments involved. Each test instrument was evaluated in the first section of this chapter.

Conclusions

Controversy over male/female cognitive differences appears to revolve mainly around differences in verbal and visual/spatial ability. This area of differences between the sexes was given wide-spread acknowledgement with Maccoby's 1966 publication of The Development of Sex Differences. Further analysis was given the subject with Maccoby and Jacklins' 1974 publication, The Psychology of Sex Differences. These two texts are widely quoted in the literature as showing evidence of the differences under questions and are used in many introductory psychology classes studying human behavior. Because of the professional background and reputation of the authors, conclusions stated in the two texts are regarded as authoritative.

Challenges to the conclusions, particularly those of Maccoby and Jacklin (1974), have come from several fronts. Block (1976a, 1976b), Hyde (1981), and Tresemer (1975) have addressed the issues and pitfalls involved in assessment of male/female differences. The reported differences, when submitted to meta-analysis techniques such as omega squared and *d* which assess the magnitude of those differences, are very small. Omega squared shows the proportion of variance in the entire distribution of scores that can be accounted for by male/female differences. Hyde reported the median omega squared scores were as follows: for verbal ability, .01; for quantitative ability, .01; for visual/spatial ability, .04; for field independence/dependence, .025. In other words, for those abilities reported by Maccoby and Jacklin (1974) to have well-established male/female differences, no more than 5% of the variance could be attributed to between-group differences.

Thus, up to 95% of the variance is due to within-group variation and/or measurement errors.

It is generally believed there exists a strong connection between visual/spatial skills and ability in mathematics (Benbow & Stanley, 1980, Herbert, 1982). Sherman (1978), reviewing the evidence of male/female differences in mathematics found numerous problems with the conclusions drawn by Maccoby and Jacklin (1974). Sherman claimed the tables upon which conclusions were based contained errors, inconsistencies and irregularities. Additionally, there was a discrepancy between Maccoby and Jacklin's recognition of the need to control mathematics background and their firm conclusion about male/female differences in mathematical ability.

Block (1976a) concluded the Maccoby and Jacklin (1974) text, as a reference work, had large problems surrounding it. "Readers seeking the state of knowledge regarding sex differences will find the book a valuable entry point into the literature, but they will need to be selective in accepting its conclusions" (p. 522).

Male/female differences do appear in verbal and visual/spatial abilities tested with the measures available. To deny that those measured differences exists is an unfounded refutation of a large body of research. However, as has been frequently brought out in this study, it is important to "look under the rug" so to speak, and examine the reported differences in depth. The following questions are germane to such a task:

1. Have the appropriate statistical techniques been applied so that true, not artifactual, differences are allowed to appear?

2. Have the results been reported with sufficient adequacy that one may make further analysis and judgment on them?

3. Was the testing instrument used the appropriate one for the behavior being studied? Is that instrument a valid, reliable measure of the behavior, one that has proven credibility?

4. How generalizable are the results produced in the testing condition to normal settings, particularly educational settings?

5. How important, in the real-world scheme of things, are the male/female cognitive differences that can be proven to exist?

6. Have generations of conditioning caused us to place a differential value on those differences which appear to exist?

The first four questions raised have been addressed in one manner or another throughout this study. The onus is on the reader to examine any research study under consideration according to those criteria. Regarding the fifth question, Hashway (1981) reported an interesting finding. In a study involving 4,899 college freshmen, Hashway concluded that male/female differences in mathematical ability has been exaggerated. Hashway's study tapped into eight mathematical domains. For the three domains in which he found significant male/female differences, those differences accounted for less than 1.5% of the variation. Although the differences between the group means were statistically significant, Hashway concluded that about 98% of the differences in mathematical achievement can be attributed to some characteristic other than sex.

From this finding, Hashway raised the question of the cost effectiveness of further research into male/female differences. Benjamin Bloom, developer of the concept of mastery learning, has stated that a variable has no practical importance to educators if it cannot be altered in the classroom or through counseling (Bloom, 1980). Hashway stated

> Sex is not an alterable variable. Moreover, sex does not appear to affect achievement greatly on minimal college mathematics survivial skills. Perhaps researchers and teachers would be wiser to address other variables that can be altered and that have a greater effect upon learning. (p. 140)

Of the six questions presented earlier, the last question may ultimately be the most important to address. Does an unequal value structure operate for male/female differences that may exist in verbal and visual/spatial skills? Is that value structure applied to recent brain research findings concerning hemispheric specialization? It appears from articles in commercial magazines (Durden-Smith, 1980; Durden-Smith & DeSimone, 1982; Gelman, 1981; Gornick, 1982) that a differential value is being attached to hemispheric functions, depending on the gender/function assumed relationship.

In addition to the valuing of assumed male/female functional congitive differences, some strange and contradictory flip-flops of logic are being overlaid on the values. Up until at least the present century, language ability, both oral and written, was regarded as an indicator of average and above intelligence. Language, a left brain function which requires linear sequential processes, was largely a male domain, in oration as well as publication. With the advent of the intelligence testing movement, it appeared that females exhibited higher language skills. From investigations into hemispheric specialization, a greater valuing began to be placed on right-hemisphere skills, and males tested out as exhibiting greater ability there, particularly in visual/spatial skills. The spatial, right-hemisphere abilities were redefined as holistic, i.e, creative, while the left-hemisphere, linear abilities were redefined as reductive and mechanical.

Frequently males have been regarded as logical, sequential reasoners (left-brain) while females were regarded as intuitive, diffused reasoners (right-brain). How the two sexes can flip-flop back and forth between the two hemispheres, depending on the attribute for which they are supposed to be dominant, requires an Alice in Wonderland type of analysis to understand. However, when one examines the popular literature, if the right-hemisphere function is believed to be a male domain, it is given a high value. If the right-hemisphere function is regarded as a female domain, such as emotion, it is given a lesser value. The same type of contradictions apply for left-hemisphere functions. This style of reasoning ignores the vital hemispheric interplay. For the normal functioning person, male or female, the intercommunication between the two hemispheres is a vital factor. Any male/female differences in right and left functioning are so small that they can be detected only by careful statistical analysis. The variance within each sex is always greater than the variance between the sexes.

In summation, the following conclusions can be drawn concerning the literature on male/female cognitive skills:

1. It is inaccurate and inappropriate to categorize either sex as being left- or right-brain dominant. It is perhaps more accurate to state that the two sexes might, for a variety of reasons, process information differently. Many factors impact on male/female cognitive

skills. These historical, biological, psychological, physiological, hormonal, cultural and educational factors are difficult to assess directly or to control for experimentally. However, their powerful influence should always be borne in mind when planning or evaluating research into cognition.

2. Research into male/female cognitive skills has many potential conceptual, methodological, and statistical pitfalls and problems which are unique and peculiar to this field. Thus, it is important to be cognizant of their existence and influence when interpreting research concerning cognition. Additionally, meta-analytical techniques tend to reduce or eliminate entirely the male/female differences in verbal or visual/spatial skills which have appeared in published research studies. Before judgments are made concerning any research results, it is prudent to ensure that the results are submitted to these powerful statistical techniques.

3. Many of the standardized tests used to measure male/female cognitive skills are inadequate for that purpose because of poor standardization, reliability and validity, or failure to obtain a pure measure of the skill in question. Subtests in a battery can vary widely in their reliability and validity, particularly concerning verbal and visual/spatial skills for males and females.

4. The purposes of education would be best served, judging from the current state of knowledge available, if concern was placed more on the similarities of the sexes rather than the differences, on rigorous evaluation of the measures used to detect cognitive differences, and on the possible differential processing approaches utilized by males and females.

If it should ultimately prove out that males and females are unevenly functionally lateralized, it would only mean they use different mental strategies to accomplish the same task, not that different levels of intelligence exist for males and females. It is to the differential male/female strategies involved that educators would do well to attend.

Recommendations for Future Research

> It was found that a course of training . . . generally led to improved ability to disregard the surrounding field in adjusting one's body to a position approximating the true upright. Further, the results of training in one kind of orientation were to some extent transferred to other kinds. The observed changes in performance, however, did not seem to involve a change in the person's initially preferred way of perceiving, but depended rather upon a greater effort to "figure things out" and an increased ability to interpret available experiences in arriving at a judgment. (Witkin et al., 1954, p. 9-10).

Witkin recognized the apparent malleability of what is presently called spatial skills. Although two of his better-known tests, the RFT and the EFT, have been cited as consistently demonstrating a male advantage in the results, from Witkin's remarks it appears that at least some spatial tasks measure learned skills, not innate immutable abilities. If Witkin's conclusion is correct, then it seems reasonable to assume that training has an effect on spatial tasks scores.

One possible future direction for research in the field of male/female cognitive differences is in the area of training effects on visual/spatial skills. It has been suggested that cultural sex-role expectations result in differential experiences for males and females and affects the development of visual/spatial skills (Maccoby, 1966; Sherman 1967, 1978). It has been proposed that the lesser degree of restriction placed on males in their ability to roam, from early childhood on, creates a training effect in visual/spatial skills (Witkin, et al., 1962). It is also believed that society encourages boys, more than girls, to engage in activities that sharpen spatial skills, such as the exploration and manipulation of objects.

Harris (1978) provided a review of research on the socialization theory and the effects of training. Cross-cultural studies produced mixed results, depending on the culture under investigation. On the effects of training, Harris concluded that much depends on the intensity and quality of the instruction. It appears, however, that the research populations used in the majority of studies reviewed by Harris were either males or college students. Again, the importance is borne out of the degree of generalizability from a select population to the general population.

Carpenter (1965), in a matched-sample study emphasizing estimation and visualization in the training procedures, was able to demonstrate significant improvement in performance on the Space Relations subtest of the DAT. For this eighth-grade population, Carpenter reported the Space Relations subtest as having a reliabilty coefficient of .93 for males and .86 for females. One drawback of the favorable training-effect results is the small sample size (N=50). Another drawback is the limited age range sampled. Additionally, there is controversy among researchers as to the strength and nature of male/female visual/spatial ability at various ages. These two factors point the way towards a future research project, as a follow-up to the present study.

It is proposed that selected subtests, from well-standardized batteries, be chosen for their reliabilty and validity in measurement of visual/spatial skills. In particular, these subtests should have persuasive content and construct validity and should have forms applicable to a wide age group. If a selected subtest does not cover a broad age range, then other tests for that age range could be used that correlate highly with the originally selected subtest, i.e., that demonstrate high concurrent validity. Attention should be paid to the reliability of the subtest across all age levels considered. Careful consideration should also be given to the input and output modes used by the subtests. Differences in modes could influence results, as they may tap into dissimilar abilities or skills.

Research studies should then be sought out which have utilized these subtests while investigating the effects of training on visual/spatial skils. Analysis of those studies should be carried out on several fronts: (a) the similarity of the population studied to the norming population, (b) the use of careful sampling procedures to eliminate bias, (c) the utilization of proper statistical techniques, such as tests of significance, $\underline{d}$, and omega squared, (d) the control of confounding variables, and (e) close similarity of the treatment variables, i.e., the training method used.

When these studies have been gathered, then further analysis should be on a deeper level than box-score counts as was used by the Maccoby and Jacklin (1974) analysis. Meta-analysis techniques, as proposed by Block (1976a, 1976b;), Hyde (1981), and Sherman (1978) would more accurately indicate true differences between males and females on the measures in question. This information would allow a plotting of the constancy of male/female differences, if any, across a broad age range, and would indicate the degree and length of the differences. If a match could then be made between this information and what is know about impacting factors on cognition, such as maturation rate, socio/cultural conditioning, functional brain specialization, and hormonal effects, then substantive conclusions might be drawn concerning not only the nature and degree of the likeness/differences, but also the implications for educators interested in raising the level of visual/spatial skills.

It is acknowledged that the situation described above is idealized in many respects. However, it is probably best practice to start from the ideal and work down to the practical and available. One final question needs to be addressed. In contemplating future research into male/female cognitive differences, particularly in the area of visual/spatial skills, the bottom-line question must be asked. In the real world, how large a difference do these differences make? Are the between-group differences that much larger than the within-group differences, or are they so small they can only be pulled out by powerful statistical analysis? Do any existing differences impact on how we live our lives, or are we guilty of taking isolated research findings, interesting as they may be, and running with them? Are males and females really that different in their verbal and visual/spatial capabilities, different enough to change the course of educational practice? In the final analysis, addressing these latter questions should be the goal of future research into male/female cognitive abilities.

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BIOGRAPHICAL SKETCH

A transplanted "native" from Long Island, Ms. Cooke was raised in Fort Lauderdale, Florida. She earned the Bachelor of Arts in Education at the University of Florida, graduating with high honors, and taught for several years at the elementary level in Florida. Many years of frequent moves as a member of a military family brought teaching experience in a wide variety of settings and cultures, both on the mainland and overseas. Returning to academia, Ms. Cooke earned the Master of Arts in Education at the University of North Florida, specializing in specific learning disabilities. Ms. Cooke is a member of several professional honorary societies, including Phi Delta Kappa, Kappa Delta Pi, and Pi Lambda Theta. Ms. Cooke has had extensive training in the field of educational media and instructional development, and is presently employed as an Instructional Developer for Science Applications, Inc., Orlando, Florida, where she is intimately involved in the development of training programs for the Tactical Flag Command Center's evolving computer-assisted decision aid system.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Lee J. Mullally

Lee J. Mullally, Chairman
Associate Professor of
Instructional Leadership
and Support

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

William H Drummond

William H. Drummond
Professor of Instructional
Leadership and Support

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Cecil D. Mercer

Cecil D. Mercer
Professor of
Special Education

This dissertation was submitted to the Graduate Faculty of the Division of Curriculum and Instruction in the College of Education and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

April, 1983

Dean for Graduate Studies
and Research